PRODUCT ENGINEERING

GEORGE F. NORDENHOLT, *Editor*

New Design Concepts

HISTORY HAS PROVED that many of the world's greatest advancements were born during war periods. In the past such progress has been greatest in the field of medicine and surgery and, undoubtedly, this present conflict will bring forth further great strides in that field. However, in this present conflict, the greater emphasis is upon the machinery of war rather than numbers of men. Relatively speaking, men engaged in actual combat are fewer but the machinery and engines of war have been multiplied many fold. It is for this reason that engineering and industry are playing a greater part in the prosecution of war than ever before. The outcome of the present conflict will depend largely on the relative merits of the scientific and industrial accomplishments of the opposing nations.

Although we are not officially in the war, American engineering and industry have already felt the impact. The first major effect of our defense program is felt in the scarcity of materials. In rapid succession, aluminum, zinc, nickel, copper and practically all other metals are being put on priority lists.

Design engineers today have a wonderful opportunity to use their judgment and ingenuity without restraint. In the present emergency the engineers are 100 percent in the saddle. They are the only ones who possess the technical knowledge and experience to dictate changes in materials and methods for economizing on materials.

Great care and good judgment will have to be exercised in switching from one material to another. Simple machine elements not subjected to severe stress or other service requirements can be changed quickly without a great deal of study. But highly stressed members or parts subjected to severe service must be studied most carefully before making any changes. The problem becomes further complicated in attempting to select a material which is not on the priorities list or for which there is some assurance that the supply will not be extremely limited.

One company has tackled the problem of materials by listing the materials that had been used in former decades. Engineering department files were ransacked for old drawings and old blueprints of designs that were manufactured before the days of the general use of alloy steel. Another line of attack was to study ways and means by which unnecessary materials or parts might be eliminated. This last is the perfect answer to the problem of scarcity of materials.

Less than 15 years ago there was still on the market a machine called the Model T. Its strongest sales argument was, "It takes you there and brings you back." Its outstanding design feature was simplicity and economy. By force of circumstances design engineers must get back to the philosophy which made the Model T famous. What is needed today is machinery and equipment for the home and industry that will render the services required, but designed as simple as possible and requiring a minimum of material and workmanship in their manufacture. The sales manager's problem today is not a question of getting the engineering department to put the greatest number of "doodads" on the product in order to sell it in competition to the general public. His biggest problem is to be in a company where the chief engineer can develop a product that can be made. It is a seller's market; the problem is to produce the products to be sold. The highest type of engineering will be required to develop products that "take you there and bring you back" and that can be manufactured with a minimum amount of materials and workmanship.

We venture to predict that in this war emergency many startling developments in the field of engineering design, especially with reference to the ingenious use of materials, will be born. In meeting today's conditions, engineers will develop a resourcefulness far beyond anything previously conceived. We are entering a period wherein new design concepts are being born and old dusty designs are being polished up.

THE MESSERSCHMITT 110

Details of Germany's Mass Production Fighter

JAMES E. THOMPSON
Service and Specification Engineer, Vultee Aircraft, Inc.

THE Messerschmitt Me 110 long-range fighter is an airplane designed for "blitzkrieg production" as well as blitzkrieg warfare. A brief examination reveals that its designers gave careful attention to the basic factors governing mass production practicability and economy—design simplification; elimination of close limits and clearances; practical assemblies and installations; and a minimum variety of structural shapes and sheet gages. Examination reveals that this airplane lacks in nothing that a high-grade military airplane should possess. Its performance is good; armament heavy; instruments and controls are adequate. Long- and short-wave CW and phone radio equipment is provided.

Production economy has largely been achieved by loosening up manufacturing

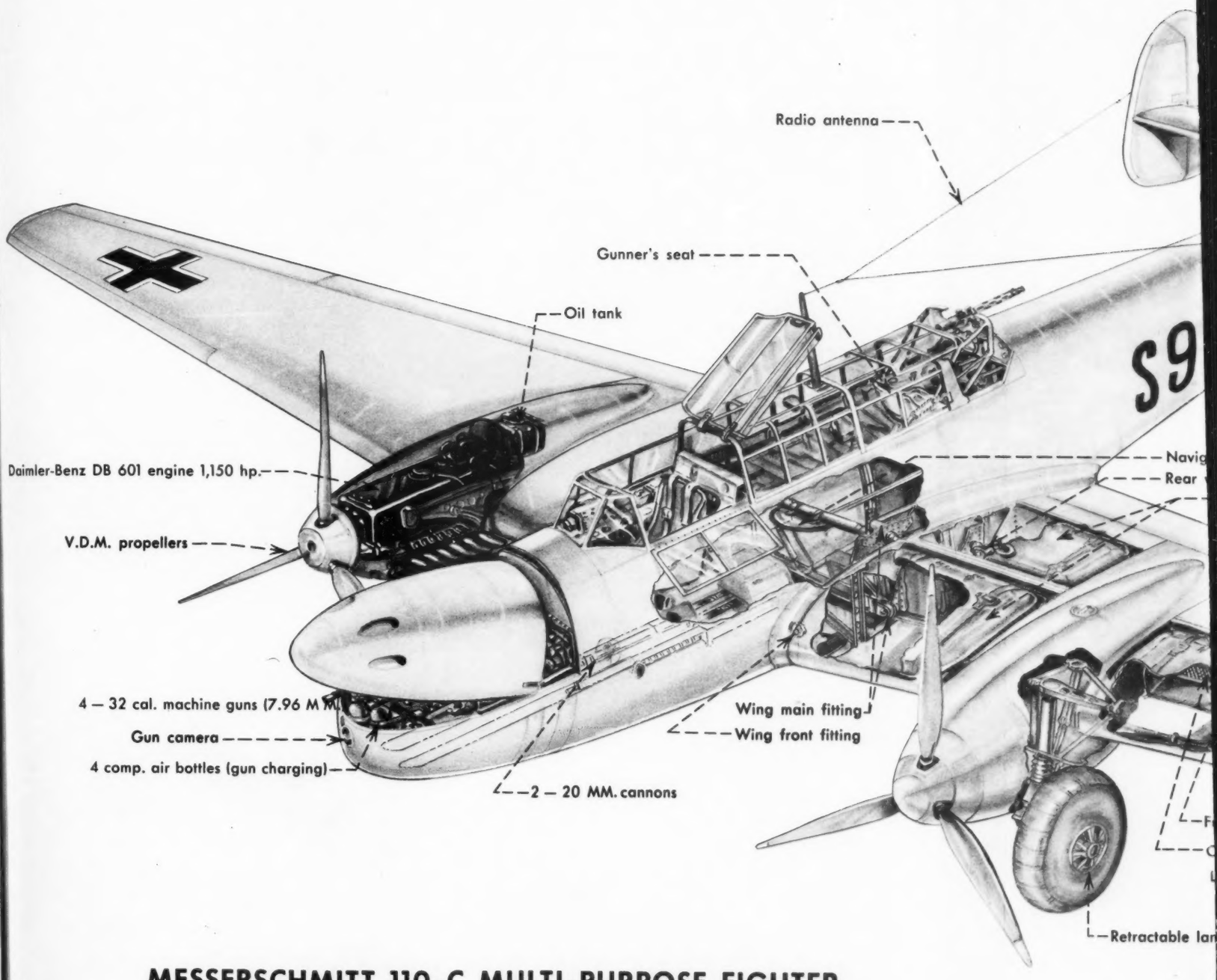
Table I—Specifications of Messerschmitt Me 110 C-1

GENERAL	
Type	Three-seater, twin-engined, low wing, land monoplane
Duty	Long Range Fighter
Overall span	53 ft. 5 in.
Overall length	40 ft. 6 in.
Fuselage maximum width	— 35 in.
WING	
Total area	414 sq. ft.
Mean aerodynamic chord	— 92 in.
Taper ratio	2.7:1
Main spar location	39% of chord
Wing loading	37 lb. per sq.ft. (approx.)
Wing weight	4.8 lb. per sq.ft.
LANDING GEAR	
Tread	15 ft. 2 in.
ENGINE	
Name	Daimler-Benz DB 601
Type	12-cylinder, poppet valve, liquid cooled, inverted Vee — supercharged, spark-ignition and fuel injection.
Fuel	87 octane min.
PROPELLERS	
Name	VDM
Type	Three-blade, controllable pitch, full feathering
Diameter	11 ft.
Control	Electric motor
ARMAMENT	
Fixed guns	Four 7.92 mm. (approx. cal. .32) — nose mounted
Cannon	Two 20 mm.—nose mounted
Flexible guns	One (approx. cal. .30)
Bombs (alternate load)	Two 250 kg.
TANK CAPACITIES	
Fuel	
Normal — 4 tanks	340 gal.
Maximum — 6 tanks	480 gal.
Oil	
Two tanks	11.5 gal. each
Fuel to oil ratio	21:1 max.
WEIGHTS	
Weight empty	9,900 lb. (approx.)
Useful load	5,400 lb. (approx.)
Gross weight	15,300 lb.
PERFORMANCE	
Maximum speed at 19,000 ft.	365 mph
Maximum cruising speed at sea level	263 mph
Maximum cruising speed at 16,404 ft	304 mph
Maximum cruising speed at 22,966 ft	301 mph
Range at cruising power and speed	565 miles
Maximum range at most economical power	1,750 miles (estimated)
Maximum duration	7.0 hours (estimated)

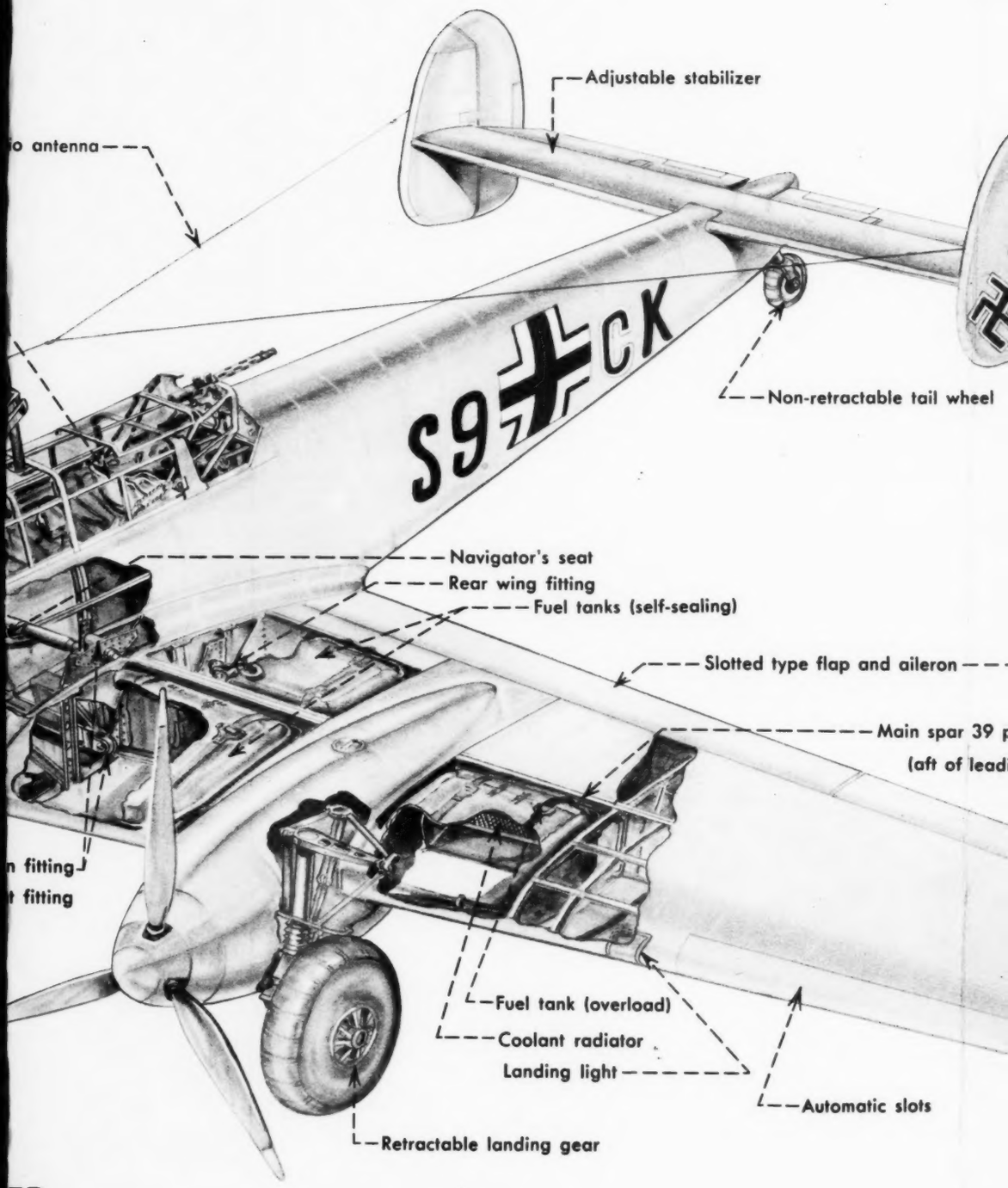
Table II—Specifications of Daimler-Benz DB 601 Engine

Type	60 deg. Inverted Vee
Cooling	Liquid — 50% ethylene glycol and 50% water
Normal maximum power (at 19,000 ft.)	1,150 hp. at 2,400 rpm*
Take-off power (for 1 min.)	1,360 hp. at 2,400 rpm
Compression ratio	6.9:1
Blower ratio	10:1 maximum
Reduction gearing	14:9
Bore	5.9 in.
Stroke	6.3 in.
Displacement	2,069 cu. in.
Length	67.5 in.
Height	40.5 in.
Width	29.1 in.
Weight (with all accessories, plumbing and wiring to firewall — dry)	1,610 lb.
Accessories: Magnetos	Bosch-twin CM12BR4
Spark plugs	Bosch — 2 per cyl.
Injection pump	Bosch 12-cyl. in-line
Injectors	Bosch — 1 per cyl.
Oil pump	Gear type
Super charger drive	Automatic, hydraulic, variable speed

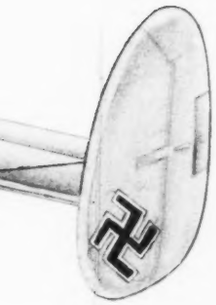
* Critical altitude of 19,000 ft. assumed on basis of airplane developing maximum speed at 19,000 ft.



MESSERSCHMITT 110-C MULTI-PURPOSE FIGHTER


Adjustable stabilizer
antenna
Non-retractable tail wheel
Navigator's seat
Rear wing fitting
Fuel tanks (self-sealing)
Slotted type flap and aileron
Main spar 39
(aft of lead
fitting
fitting
Fuel tank (overload)
Coolant radiator
Landing light
Automatic slots
Retractable landing gear

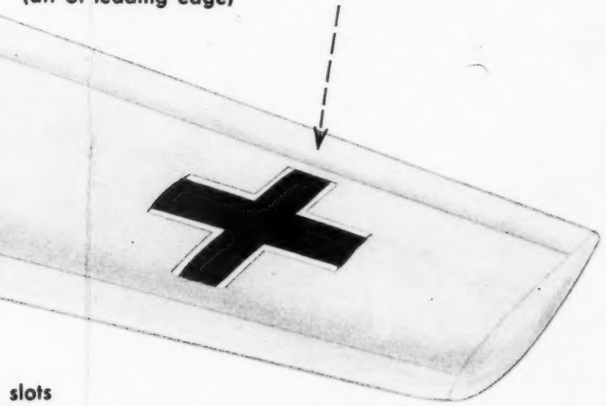
ER



le tail wheel

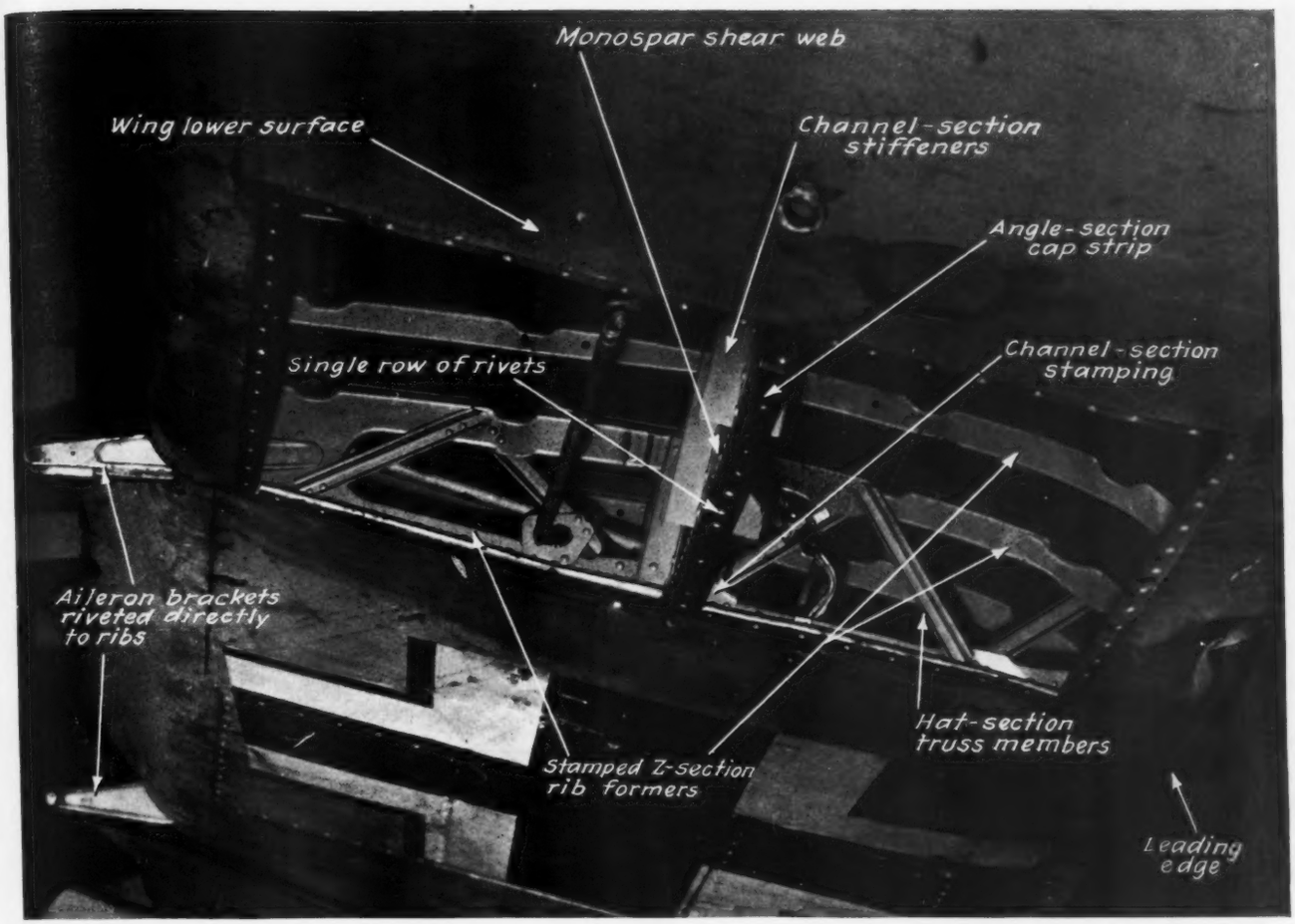
l aileron

Main spar 39 percent of chord
(aft of leading edge)



slots

K. RANDALL



Messerschmitt 110 wing construction—outboard of engine nacelle, designed for ease of fabrication and assembly

limits as much as possible by ingenious design. Interchangeability of wing fillets is a troublesome problem in aircraft production, as it is necessary to hold close dimensional limits on the attachment screw holes in a part that is curved in three dimensions, and extremely flexible. This problem is solved by piercing large attachment holes in the fillet itself, and using attachment strips that clamp the fillet edges between strip and wing or fuselage. This design permits drilling of attaching screw holes in strips and wing or fuselage with matched drill-jigs to insure perfect alignment, and the large holes in the fillet itself permit considerable dimensional variation of this part.

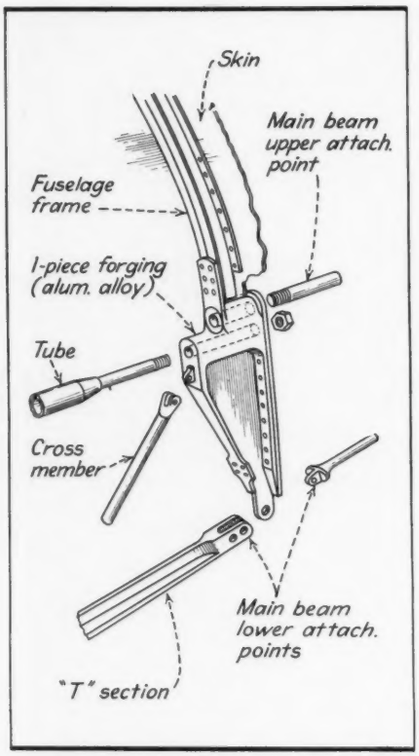
A similar problem of dimensional variations between wing tips and panels is met by special washers, screwed down over attaching holes in the skin. The attaching holes in the tips are large enough to compensate for variations in the location of mating holes in either section of the wing.

An unusual design permits considerable fore and aft and vertical adjustment of the nose-section wing fittings for alignment at final assembly. The fitting mounting face and pad are finely serrated, and the mounting bolt holes are oversize to permit adjustment of the fitting—with shear loads being transmitted through the serrations, rather than through the bolts.

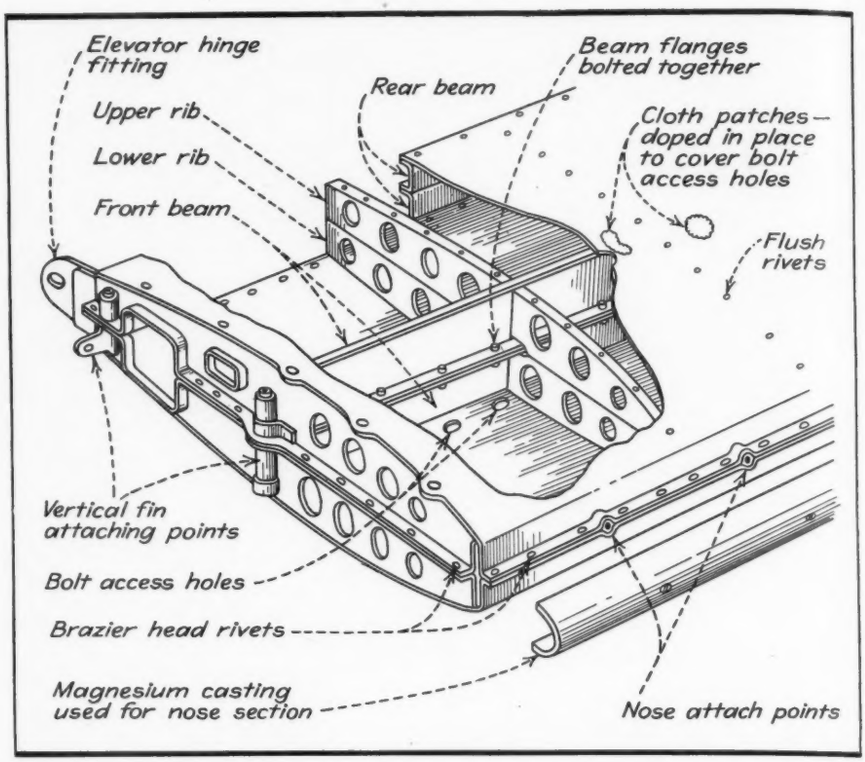
Self-aligning bushings for the majority of attachment fittings greatly simplify final assembly operations. These bushings are also used as rod-end bearings for the engine control rods, and appear to be a standard part as their

Table III—Materials Used in Messerschmitt Me 110

WING	
Basic structure	Aluminum alloy
Secondary structure	Aluminum alloy and magnesium alloy sheet
Average skin thickness	0.015 in.
Nose skin thickness	0.060–0.075 in.
Maximum skin thickness	0.081 in.
FUSELAGE	
Basic structure	Aluminum alloy
Secondary structure	Aluminum alloy
Pilot's and gunner's seats	Magnesium alloy
Average skin thickness	0.045 in.
EMPENNAGE	
Basic structure	Aluminum alloy
Stabilizer nose section moldings	Magnesium sand casting
Average skin thickness	0.055 in.
POWER PLANT	
Engine bearers	Magnesium forgings
LANDING GEAR	
Wheels	Magnesium castings



Wing panels connect directly to fuselage structure through four-point attachment

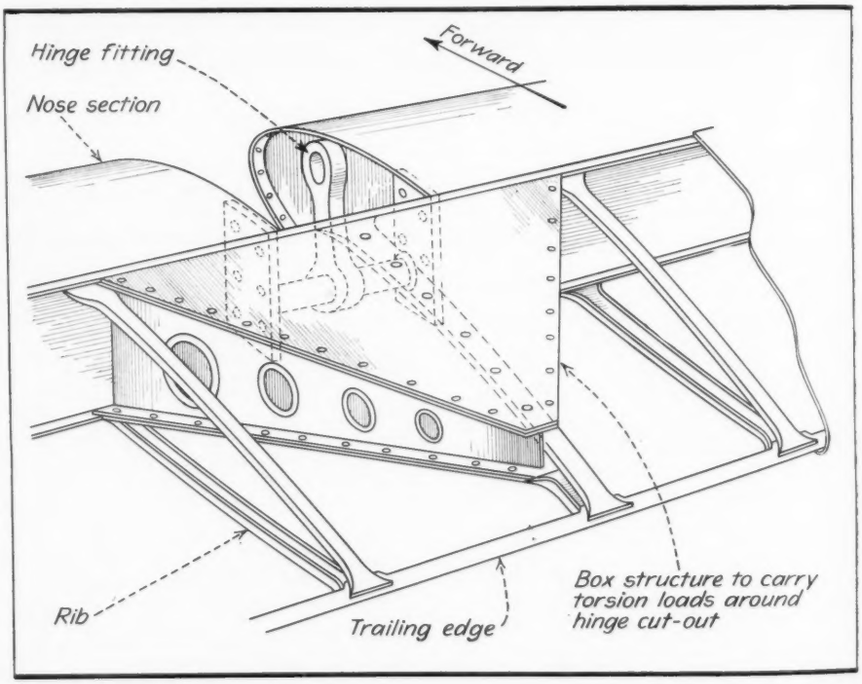


Unique construction of horizontal stabilizer for rapid manufacture and ease of assembly. Sub-assembled halves are joined by bolts

nature is such that quantity production would be a simple matter. Each bushing assembly comprises two steel parts, an outer socket ground on its I.D. to a spherical radius, and an inner bushing with its O.D. ground to a mating spherical radius. One side of the outer socket is notched with two reliefs spaced 180 deg. and slightly wider than the inner bushing. This permits assembly by turning the inner member at right angles to the outer part, slipping the two together, and rotating the inner member into line with the outer. The assembled bushing has a ball-and-socket effect, permitting angular alignment over an unusually wide range.

It is obvious that the designers of the Me 110 concentrated every effort upon developing a structural design so well adapted to mass production that any reasonable accelerated production schedule could be met, and one which permits manufacture of completely interchangeable major components in widely scattered shadow factories, to be later assembled at one or more centrally located assembly plants, without regard to what factory produced a particular subassembly.

Examination of the airframe reveals that every factor affecting production was carefully weighed during the design of the Messerschmitt, even the consideration that the majority of assembly and fabrication must be possible of accomplishment with semi-skilled labor



Control surface nose section design. Box structure carries torsion loads around hinge

in the event that accelerated production and the demands of military service should bring about an acute shortage of skilled labor. This belief is substantiated by the code numbers placed on a majority of assemblies to indicate the attaching parts, such as the two halves of an electrical disconnect plug being marked "L-93," or one end of an oil line and its mating fitting both being marked "F-17."

In order to analyze intelligently the production possibilities of the Me 110, it is necessary to assume that manufacturing methods and equipment used by Messerschmitt are similar to those of

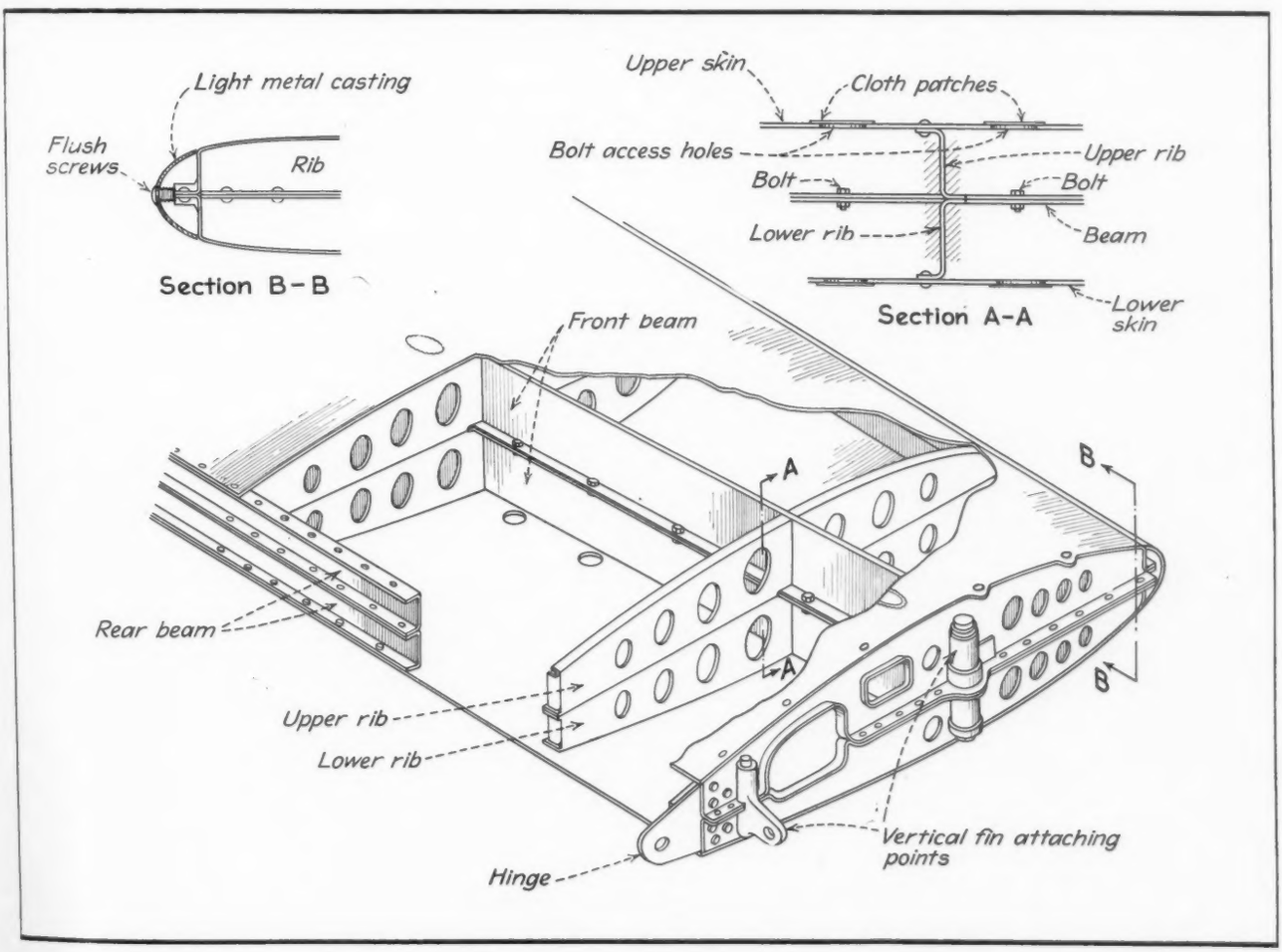
American factories and then examine each portion of the airframe with a view to its adaptability to mass production by these assumed methods.

The semi-monospar, all-metal, two-panel wing construction lends itself well to quantity production, without requiring the use of elaborate wing jigs or the services of highly skilled workmen. The simplicity of the wing internal structure, of true monospar construction outboard of the engine nacelles, with accessibility provided through landing gear cut-outs and large removable panels for fuel tanks and control mechanisms, makes possible rapid assembly. Detail parts are simplified by minimizing the variety of structural sections and by largely eliminating extruded sections.

The basic wing construction consists of a nose section formed in a power brake operation; nose ribs formed with a punch-press or drop-hammer; hat-section stringers formed from strip stock with power rolls; and main beam comprising extruded aluminum-alloy angle cap-strips riveted to an aluminum alloy plate shear-web member. Aft ribs of the Warren-truss type are formed by riveting short lengths of hat-sections to a former practicable of manufacture as a stamping or a hammer part. Flat sheets of aluminum alloy are flush-riveted into place to cover the wing aft of the nose section, with flush joints being obtained by joggling the edges of overlapping sheets. The wing construction is simplified by the complete absence of a rear beam outboard of the engine nacelles, aileron and flap loads being transferred directly into the monospar by the trailing edge ribs.

The absence of a wing center-section structure further simplifies wing fabrication. The wing panels connect directly to the fuselage structure through a four-point attachment between the shear-webs and the fuselage structure. The monospar is connected at two points to a truss-girder passing through the fuselage: a bolt passing through a clevis fitting to connect the bottom of the spar, and a large stud extending from the top of the spar through a boss in the truss within the fuselage. Torsion loads in the nose section torque box are carried into the fuselage by a clevis connection between the nose section sub-spar and the fuselage. Another clevis connection, near the aft of the wing, permits the rear sub-spar to carry aileron and flap torsion loads into the fuselage. Square-cut wing tips, in the form of simple fairings to close the outboard end of each wing panel, facilitate production of the wing.

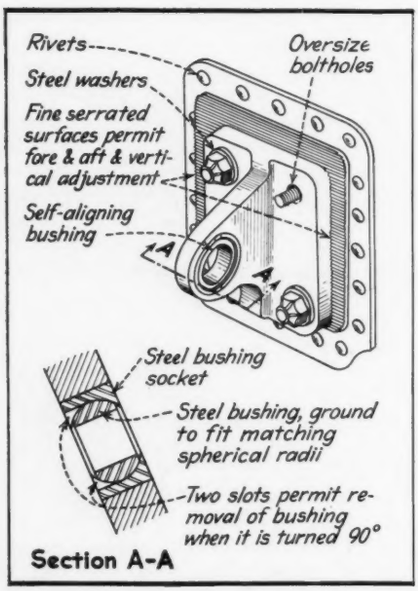
Six self-sealing fuel tanks are housed within the wing structure, four within the nose section, with one being at each side of both engine nacelles, and two more aft of the monospar and inboard of the engine nacelles. Each tank is readily removable from the wing through a stressed-panel, secured by machine screws, in the wing skin immediately below the tank. The tank construction comprises a riveted fibre frame, similar in construction to a suitcase, and used solely to give shape to the tank, with no attempt being made to have a gasoline-tight frame. This tank frame is placed inside a special container, which can be best described as being a rubber envelope with a large flap strapped over the top of the tank frame to completely inclose the tank. A thick blanket of synthetic crepe rubber is provided on the inside of this flap for sealing purposes. The self-sealing characteristics



Horizontal tail structure. Holes pierced in skin sheets permit bolting of front beam flanges for assembly

of the tank are obtained by using a laminar envelope construction comprising several layers of pure rubber held between an outer layer of tough vulcanized rubber, and an inner-layer of gasoline-resistant synthetic rubber.

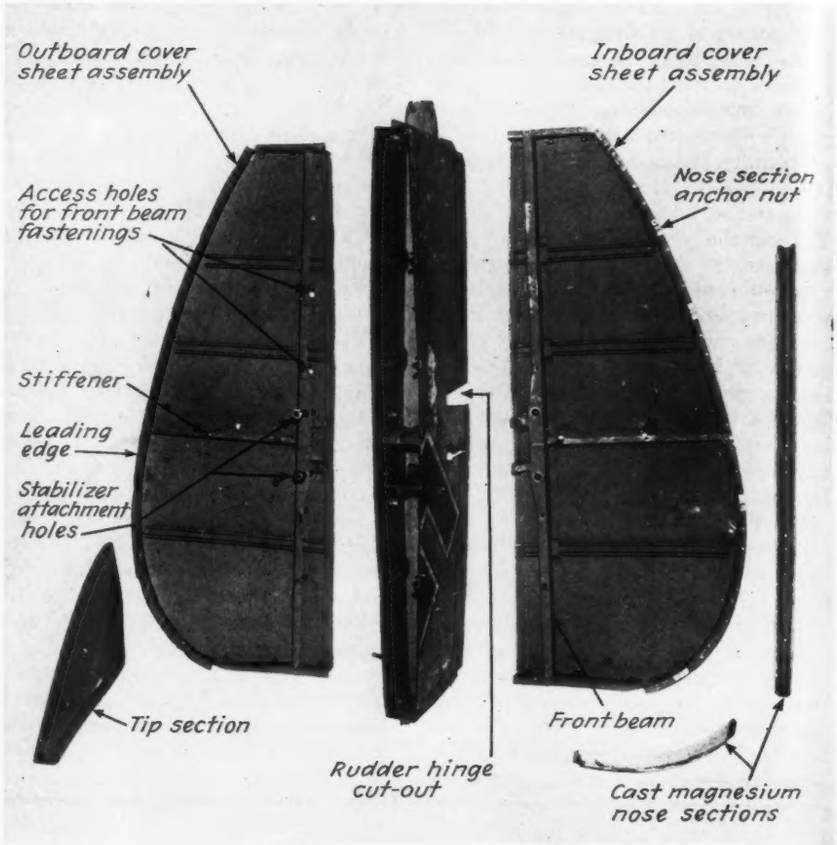
When this envelope is pierced by a bullet the normal resiliency of the rubber layers is usually sufficient to close the wound, and the slight seepage of fuel into the layers of pure rubber causes these to rapidly swell and tightly seal the puncture. The effectiveness of this type of construction is surprising, as firing tests have shown such tanks capable of satisfactorily sealing the punctures caused by several direct hits of machine gun bullets concentrated within a small area. A self-sealing oil



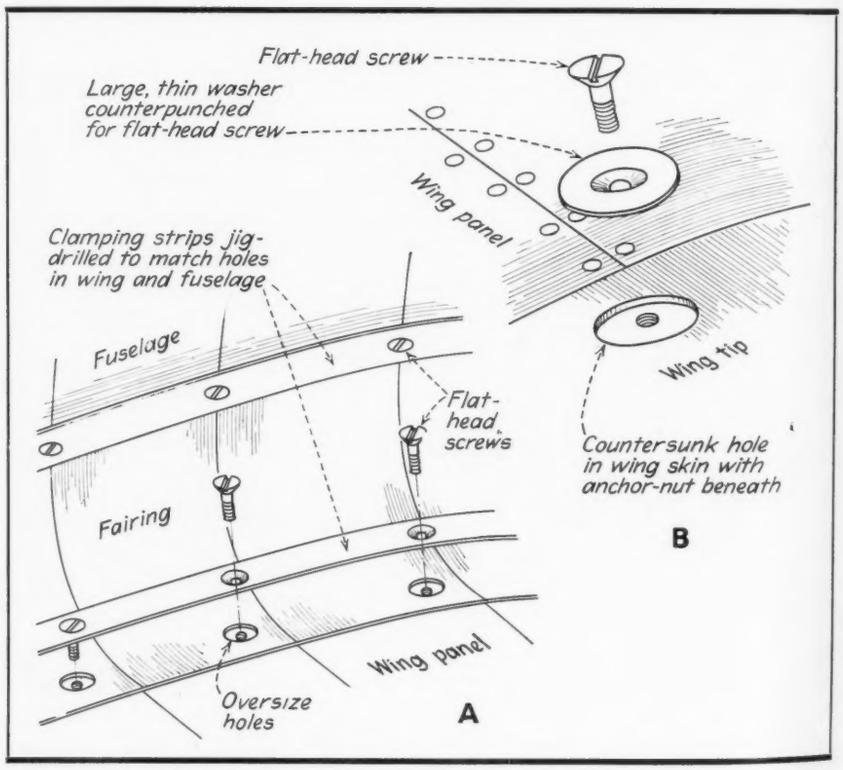
Fore and aft and vertical adjustment provided by oversize holes and serrated faces

tank of similar construction is mounted within each engine nacelle. Each self-sealing tank is supported in a non-metallic frame by fabric straps, with the obvious intent of avoiding damage from metal "orange-peel" caused by bullets.

The design of the vertical and horizontal stabilizers permits these to be manufactured rapidly and easily in quantity production. The basic structure of each comprises symmetrical halves, riveted and bolted together in an ingenious fashion, with a cast magnesium nose section being attached with flush screws; and can best be visualized by considering a conventional stabilizer divided longitudinally along its chord line to form two symmetrical halves, with all rib and beam edges being flanged. These halves are manufactured as sub-assemblies and then joined by riveting through mating flanges around



Vertical stabilizer is fitted with cast magnesium nose sections



Dimensional variation between wing tips and panels is compensated for by special washers, shown at B. At A, oversize attachment holes in wing fillets and jig-drilled attachment strips save much fabrication and assembly time

the entire outside edge, with the flanges of the front beam being joined by bolts inserted through holes pierced in the skin sheets. The bolt access holes are closed by small cloth patches doped in place. The vertical stabilizer construction is simplified by low applied loads which permit substitution of chord-wise hat-section stiffeners for the ribs.

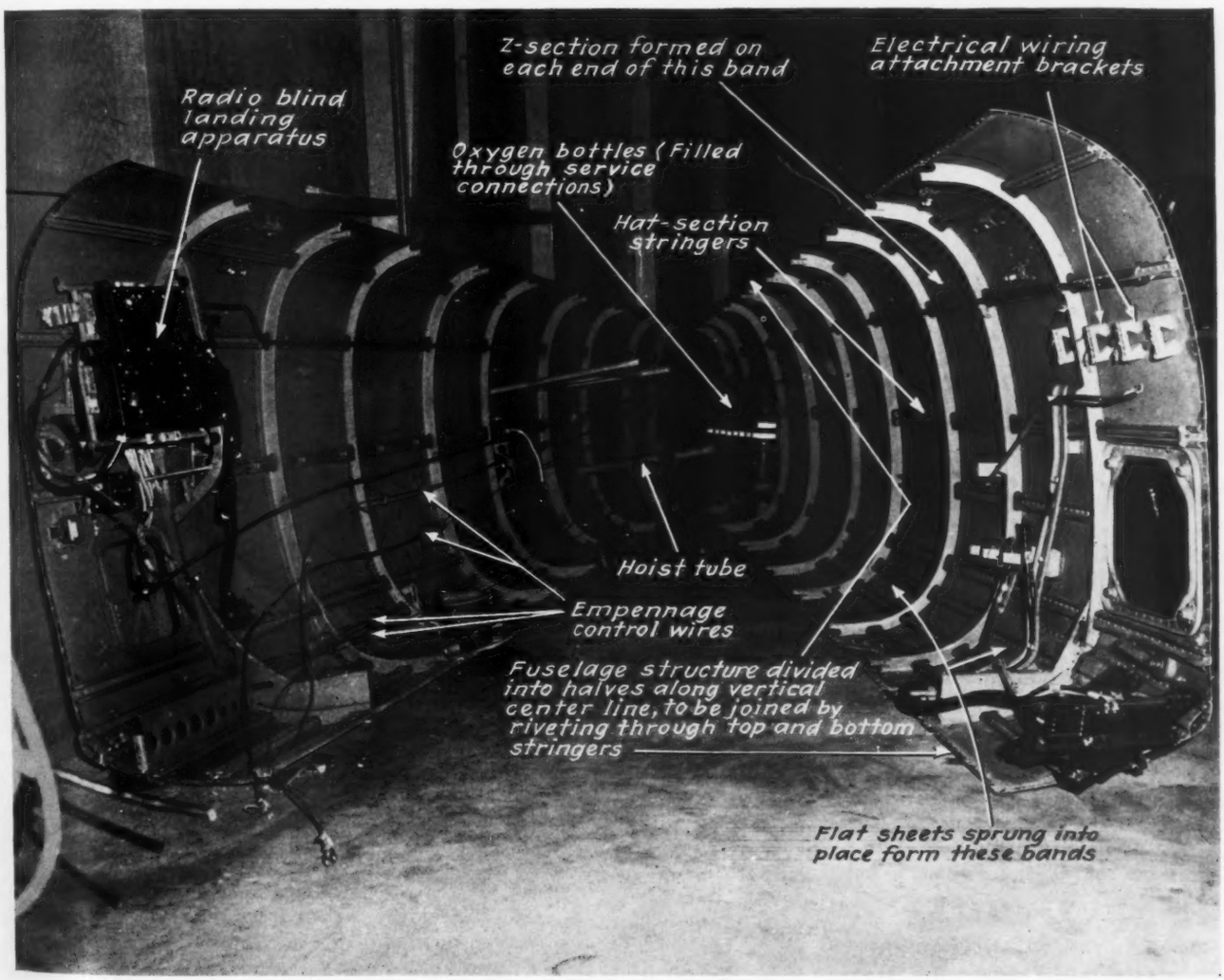
The structural units forming the ailerons, rudder, elevators, and wing flaps are designed for economical production, with the majority of their parts being practical of fabrication by simple power-brake and punch-press operations. A power riveting machine could be used for quickly joining these units into a frame assembly of nose section, beam and ribs, preparatory to the final operation of covering with smooth, flush-type fabric.

The hydraulically-operated, slotted-type wing flaps extend from fuselage to aileron on each wing panel and are interconnected with the adjustable horizontal stabilizer to automatically trim the ship to compensate for a nose-heavy condition resulting from the drag of the lowered flaps. A toothed rack, connected to the left-hand side bellcrank, engages a small pinion driving a cable leading aftward and connecting with a chain around the drive sprocket of a screw-jack which is hinged to the leading edge of the horizontal stabilizer. The arrangement is such that as the flaps are lowered, the stabilizer leading edge is lowered about two inches. Automatic wing slots are fitted to the wing leading edge to further reduce the landing speed by preventing wing tip stalling.

Flight controls, in the form of conventional control stick, and rudder pedals with tow-brakes, are provided in the front cockpit only. All possible parts of the control system have been designed as bench sub-assemblies, permitting installation of the control system in the form of a comparatively small number of units.

The almost complete absence of lateral bracing structure within the fuselage permits direct control system routing, with a minimum of fairleads and bellcranks for the empennage control system. This system comprises steel-wire control for the rudders and elevators, and push-pull rod control for the trim tables. A system of bellcranks and push-pull tubes controls ailerons.

The fuselage structure is a simple semi-monocoque type extending from nose to tailwheel bulkhead. The basic design is such that it is adapted to mass production. It is manufactured in symmetrical halves, joined vertically along the center line to form the complete structure. These halves could be assembled in simple vertical jigs arranged to give the workmen free access to both exterior and interior surfaces of the half, thus tremendously accelerating production by eliminating the necessity of working in a close, cramped fuselage interior during assembly operations, permitting a greater number of personnel on assembly operations. It is reasonable to believe that a majority of the


Z-section formed on each end of this band
Electrical wiring attachment brackets
Radio blind landing apparatus
Oxygen bottles (Filled through service connections)
Hat-section stringers
Hoist tube
Empennage control wires
Fuselage structure divided into halves along vertical center line, to be joined by riveting through top and bottom stringers
Flat sheets sprung into place form these bands

Fuselage is manufactured in symmetrical halves and is joined by riveting along upper and lower centerlines

electrical wiring, plumbing and control mechanism within the fuselage is installed in each half while it is still in the jig, and freely accessible.

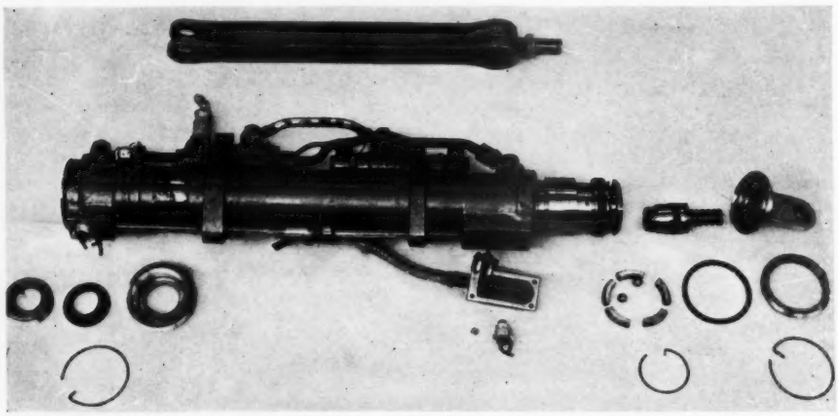
The fuselage structural design has bands of aluminum-alloy sheet about 19 in. wide, with the edges of each alternate band being rolled over into a Z-section to form integral bulkhead rings. Bands adjacent to the formed sheets are simply flat sheets sprung into place, with the whole joined by flush riveting and joggled joints to form a structure free of internal bracing members. Reinforcing extends aftward from the nose section bulkhead to the rear cockpit, and hat-section stringers extend the length of the fuselage. A main beam truss comprising a T-beam lower member and a tubular upper member connects across the fuselage. Each skin sheet extends from the lower to the upper center line and the fuselage halves are joined in a final assembly operation by two rows of rivets passing through hat-section stringers on the upper and lower center lines.

A hydraulically-operated, fully-retractable main landing gear is used, with the landing gear "legs" being folded aftward and up into retracted position within the engine nacelle lower fairings, and completely inclosed by automatically operated doors, extending the length of the nacelle fairings. Actuation is accomplished by an hydraulic cylinder connecting to the center of a knee-structure, with the result that compression of the cylinder lifts strut and wheel into retracted position. The hydraulic system uses a normal operating pressure of approximately 2,000 lb. per sq. in., and the landing gear mechanism is simplified by automatic locks, for extended and retracted positions, built within the actuating cylinders. Thus, each landing gear installation comprises but a pivoted cantilever shock absorber strut and wheel assembly, a knee-strut, and an hydraulic actuating cylinder.

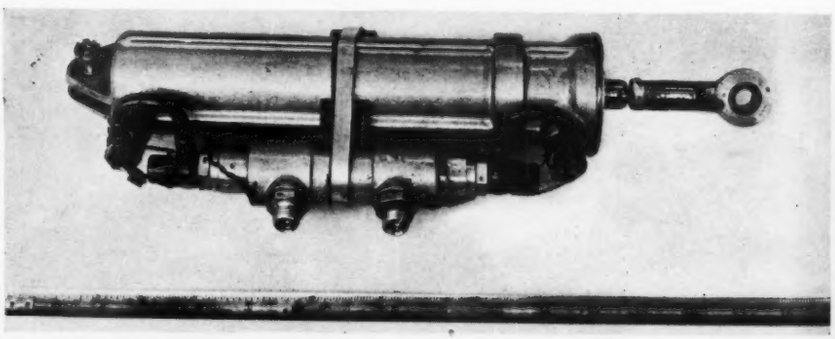
The integral locks are in the form of segment rings encircling both ends of the actuating cylinder's piston, and arranged to be forced into locking grooves at the cylinder ends by the action of a tapered cone inside each end of the piston. These lock rings can be released only by hydraulic pressure forcing the locking cone into unlocked position when fluid is applied for reversal of the piston stroke, as no normal force applied externally on the piston rod will dislodge the lock ring segments. A compressed air system provides for emergency actuating of the landing gear, with air stored in small cylinders at approximately 2,200 lb. per sq. in. pressure. Manually-operated hydraulic wheel brakes are used. The majority of the landing gear units are interchangeable, left with right. Standard tire and wheel assemblies are used.

A simple, straight-forward power plant design is used for the Messerschmitt Me 110, comprising an engine mount formed from four sturdy magnesium forgings, each attaching to a fitting at the wing monospar. The complete power plant installation is readily removable from the airplane by disconnecting a few lines and control rods. In fact, the complete installation is undoubtedly assembled as a unit, and then quickly connected to the wing during final assembly operations.

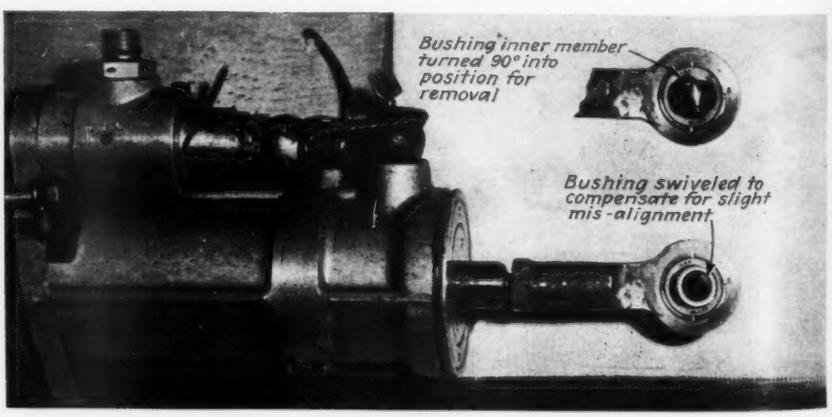
All control rods and bellcranks are obviously standard parts, identical with those used in other German military aircraft, and of a type originally developed by Junkers, wherein serrated faces on bellcrank levers are clamped between flanges on a torque rod or bracket bushing, to permit adjusting the lever or levers to the proper angle for a particular application. Piping, end fittings, clamps, many brackets, and the like are also standard parts. This practice of standardizing all engine installation parts is greatly assisted by the fact that



Hydraulic landing gear actuating cylinder. Half of knee strut shown at top



Hydraulic actuating cylinder for wing flaps



Self-aligning bushing, used extensively on the Messerschmitt plane

practically all German military airplanes are equipped with either a Daimler-Benz, or a Junkers Jumo engine, and both these have approximately the same overall dimensions, connections and control locations, permitting the use of identical mounts for either engine.

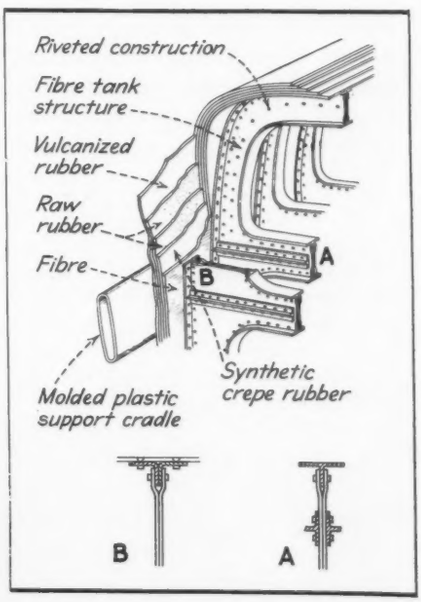
Each engine drives a three-blade, electrically controllable propeller of about 11 ft. diameter. These propellers are not a constant-speed type, and are constructed quite differently from our Curtiss electric propeller, as each blade is provided with a worm sector and pinion near the blade root, with a spur gear on each pinion shaft meshing with a large ring-gear concentric with, and driven by, an annular-type electric motor mounted directly behind the propeller on the propeller support shaft. Connection of propeller support shaft to engine propeller shaft is through a flange coupling having mating flange faces deeply serrated so as to relieve the clamping bolts of shear load. An automatic electric timing device prevents engine operation at take-off power for more than one minute at a time.

A coolant radiator for each engine is provided beneath the wing, in positions immediately outboard of the engine nacelles and just forward of the wing flaps. Each radiator has an electrically controlled air exit shutter. The absence of a rear spar at these locations permits the radiators to extend upwards for the depth of the wing, greatly minimizing the exposed, or frontal area presented to the air stream. This fact, in conjunction with placing the radiators in a location where a disturbance of air flow will have slight effect on the wing efficiency, gives the ME 110 an extremely favorably coolant radiator installation. Coolant is a mixture of ethylene glycol and water. An oil cooler is mounted beneath each engine.

Five machine guns and two cannons give the ME 110 terrific striking power as a fighter or as an attack airplane for strafing troop concentrations and transportation units. These same airplanes, as a matter of fact, were used during the Polish campaign to disorganize rail transportation, by flying along railroad tracks and disabling locomotives with explosive shells from their cannon. Four fixed machine guns, of about .32 caliber, are neatly arranged on a deck in the fuselage nose section, with ammunition boxes providing about 800 rounds for each gun located beneath the guns. The 20 mm. cannon are installed in the extreme lower portion of the fuselage beneath the pilot's cockpit, and fire through steel blast tubes extending through the lower portion of the fuselage nose section. Selective command of guns and cannon is through firing switches on the pilot's control stick. Compressed air charging (cocking) and electric solenoid firing control is provided for guns and cannon. The gunner is furnished with a single flexible machine gun, of about .30 caliber, supported in a universal mount for tilting and/or swiveling through a wide range. The gunner fires from a seated position in a swiveling bucket seat. 500 rounds of ammunition are supplied for the flexible gun. No armor plate is used in the airplane.

Two bombs of the 250 kg. class can be carried on an external rack provided with electric control. This rack is quickly detachable ,and obviously is carried only on bombing missions.

Electrical wiring is shielded throughout the airplane, for the obvious reason that the saving in installation time possibly by using prefabricated wiring assemblies, joined by disconnect plugs and connector blocks, fully compensates for the increased cost of shielded wiring. Rigid conduit is used only for mechanical protection of the wiring, and very rarely, with junction boxes being conspicuous by their absence. Fuses are entirely replaced by circuit breakers, which also serve as switches for their respective circuits. Wiring is secured to the airplane by narrow metal bands joined by a crimp, and passed through snap rings clipped into small channel members attached to the structure.



Composite construction of self-sealing fuel tank, supported on a plastic cradle

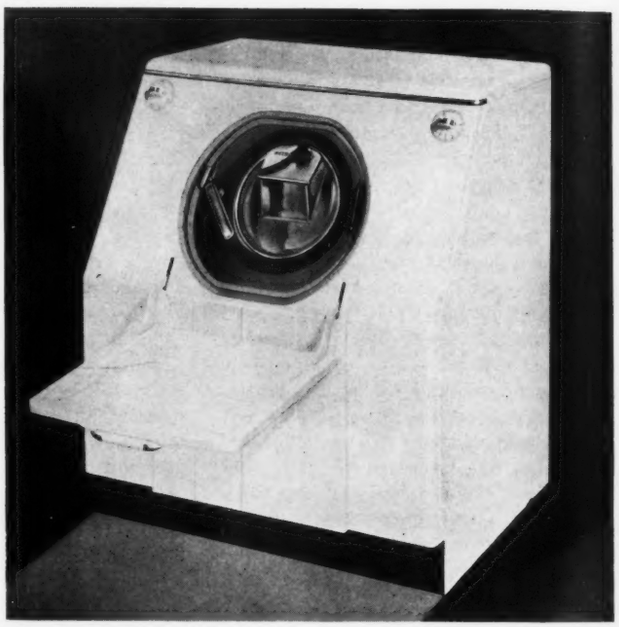
20 mm. cannon and explosive shells, compressed air charged and electrically fired

Unfolded copies of complete Messerschmitt drawing may be obtained free upon a request addressed to the Editor

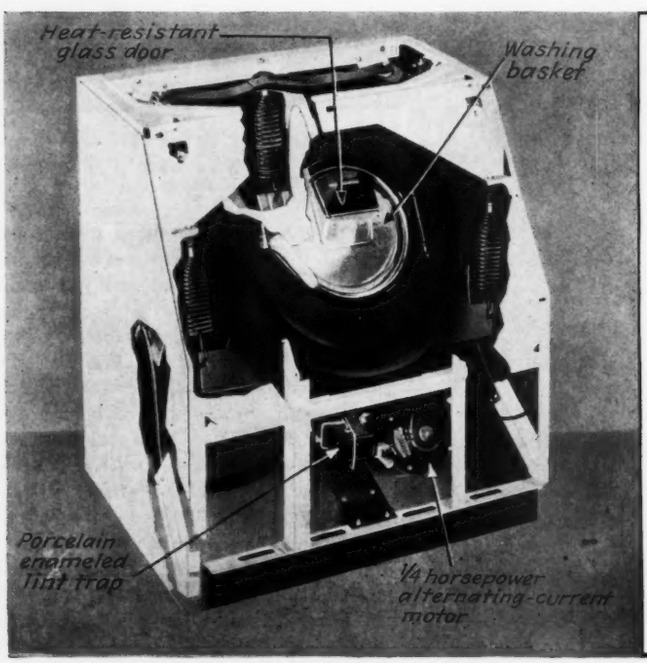
Modern Designs

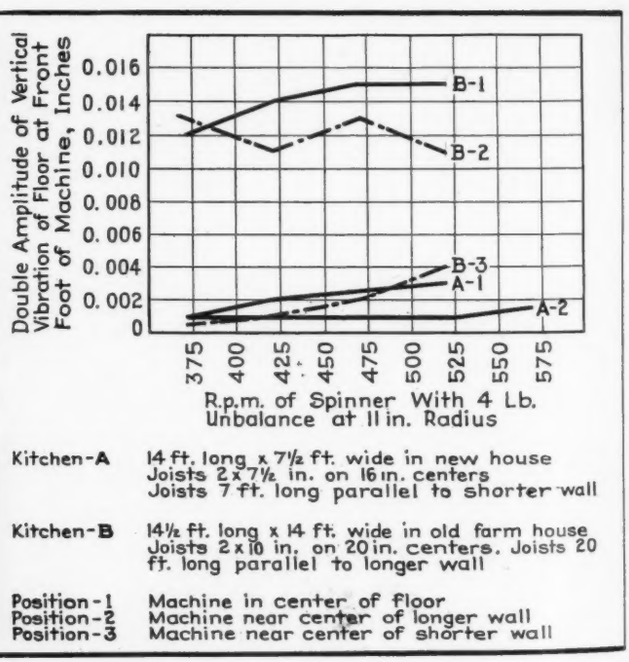
Damped Springs Isolate Rotating Mass

Severe unbalanced conditions, which result from non-uniform loading of the spinner basket, and which cause noise and vibration, have been eliminated in the new fully-automatic Westinghouse Laundromat by combining coil spring mounting with friction damping. Thus there is no need to anchor the machine to a special foundation, and it may be moved easily if necessary. Automatic cycle control dials are marked for type of material and degree of soil rather than for temperature and time. Interlocks prevent premature spinning.

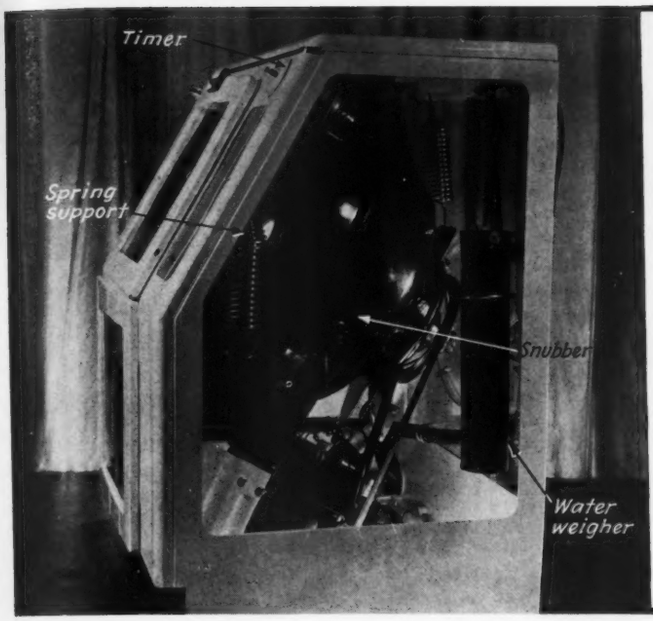


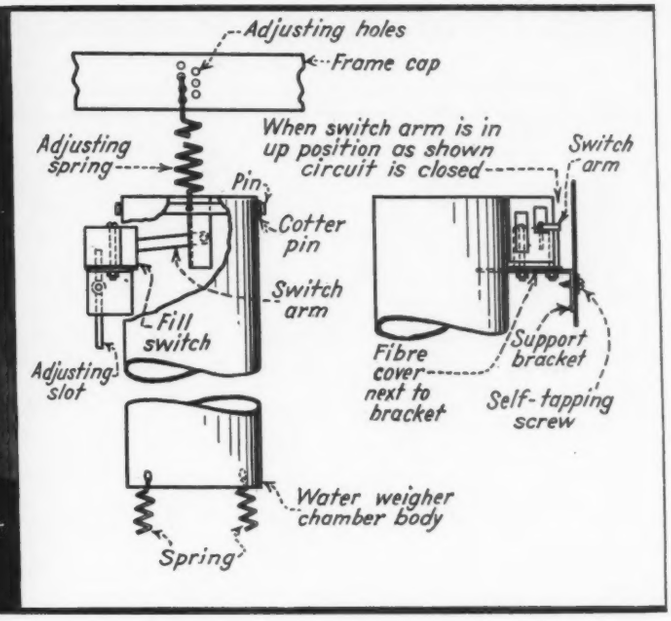
All-welded steel cabinet is bonderized and finished in baked white Dulux. Lint trap and driving mechanism are accessible through hinged panel at lower right. Loading door has glass window mounted in a one-piece stainless steel bezel; it is held against a molded rubber gasket on the tub by spring hinges. Soap chute is integral with glass window. Basket access door in upper panel serves as loading shelf when open.



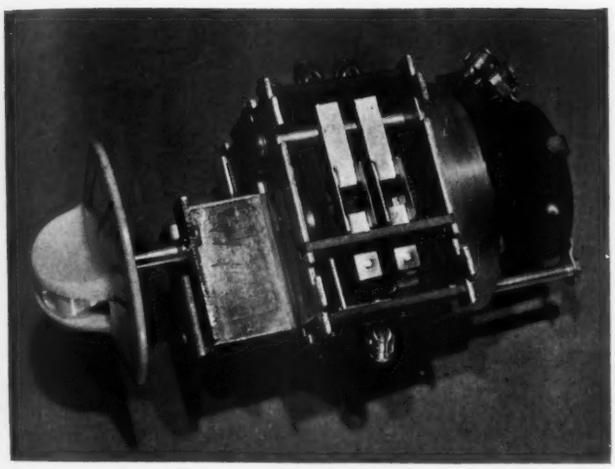

Double Amplitude of Vertical Vibration of Floor at Front Foot of Machine, Inches
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0
B-1
B-2
B-3
A-1
A-2
375
400
425
450
475
500
525
550
575
R.p.m. of Spinner With 4 Lb. Unbalance at 11 in. Radius
Kitchen-A 14 ft. long x 7½ ft. wide in new house Joists 2 x 7½ in. on 16 in. centers Joists 7 ft. long parallel to shorter wall
Kitchen-B 14½ ft. long x 14 ft. wide in old farm house Joists 2 x 10 in. on 20 in. centers. Joists 20 ft. long parallel to longer wall
Position-1 Machine in center of floor
Position-2 Machine near center of longer wall
Position-3 Machine near center of shorter wall

Vibration isolation is accomplished with steel coil springs at three points, two at front and one at rear, which support entire washing unit, including motor and pump. Damping is provided at five points, a minimum of two are effective in all modes of vibration. Round molded brake lining shoes rub on chrome-plated steel surfaces. Shoes are mounted on end of leaf springs. Curves show results of field tests on vibration damping properties.

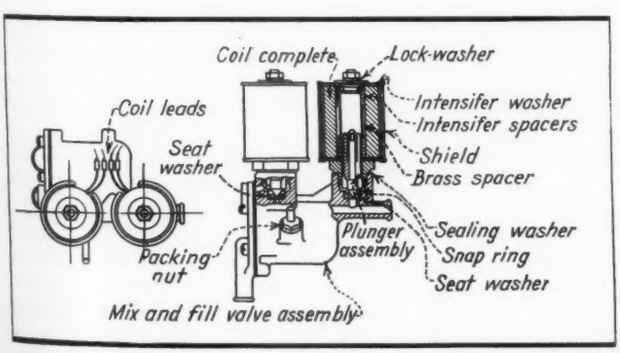


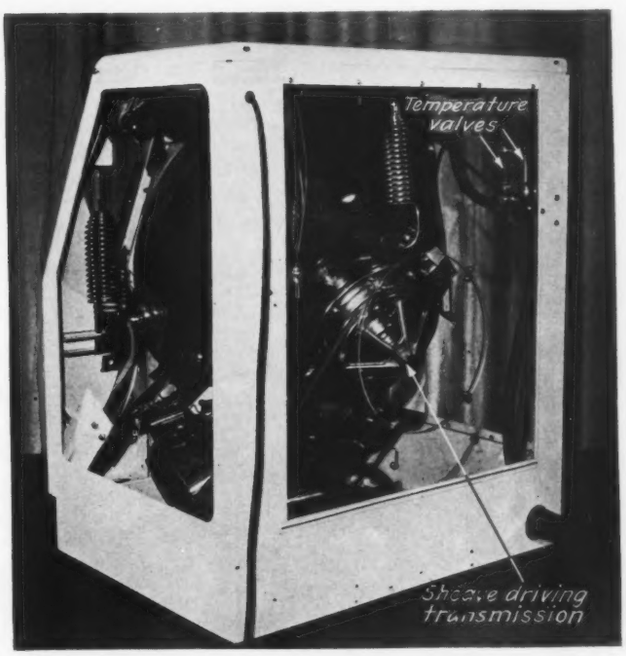


Water level is automatically controlled. A vitreous enameled steel chamber is suspended on springs to eliminate friction losses which would introduce variation in the water control. Connected to the bottom of the tub by a rubber hose, the chamber when filled to adjustable height actuates a snap-acting switch through a bracket arm arrangement, shown at right. Level of water can be adjusted by proper positioning of upper spring.



Timer, heart of the automatic control, is a micarta cam and contact arrangement driven by a synchronous motor through an escapement mechanism that permits 5 deg. rotation of the cam shaft at 45 sec. intervals, thus providing snap-acting contact operation. Timer is connected to operating elements with unified wiring harness. Timer controls introduction and draining of water, giving washing cycle of 21 min. Also changes basket rotation from 52 r.p.m. for washing to 500 r.p.m. for centrifugal extraction.

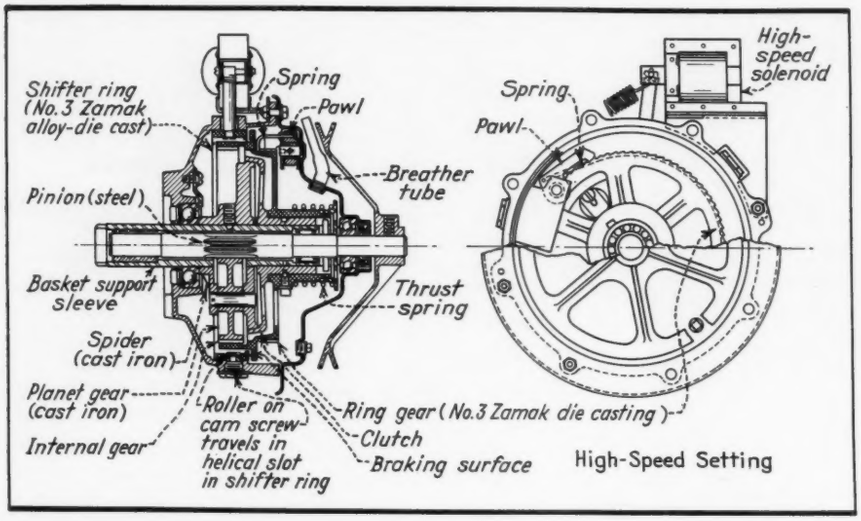




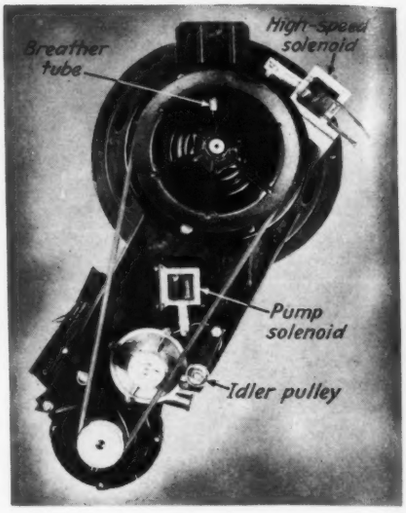
Temperature and flow of water is regulated by an automatic mix and fill valve. Temperature regulation is obtained by dial adjustment of spiral bimetallic element to the type of material. Dial, mounted on front of cabinet, operates on hot and cold lines through balanced orifice arrangement. Filling circuit and high-speed operation of the basket are interlocked through the fill switch controlled by the water weigher. Premature spinning is prevented by an interlock with fill switch.

(*Continued on next page*)

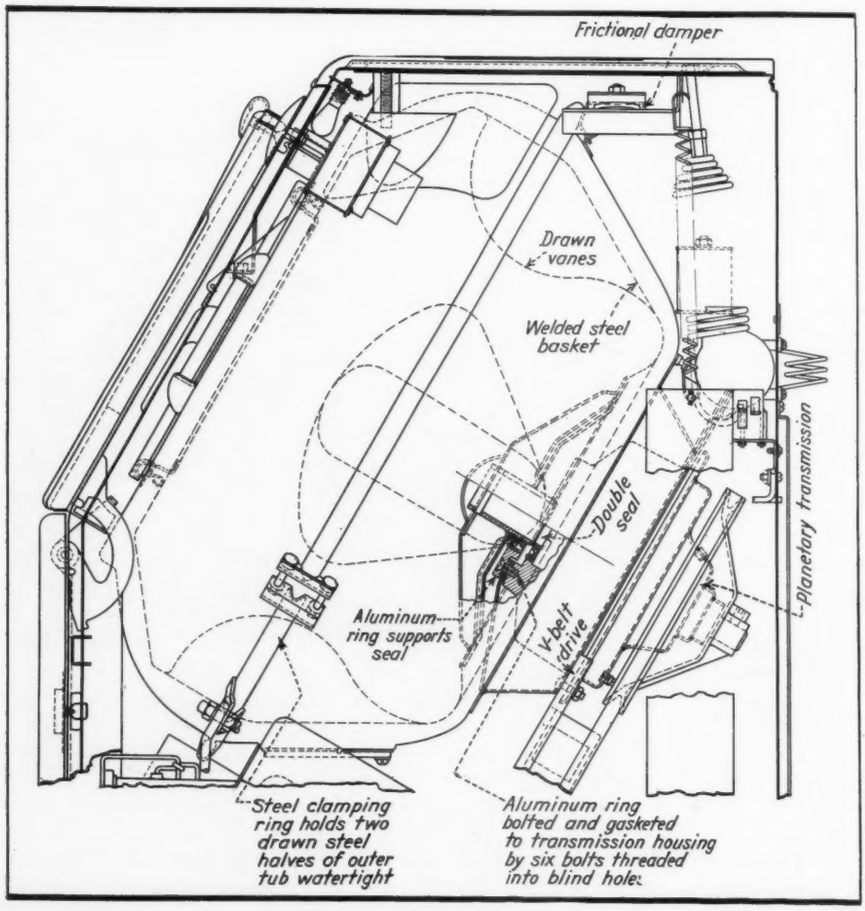
MODERN DESIGNS – Automatic Washer *(continued)*



Two-speed planetary gear arrangement, V-belt driven by a ¼ hp. washing machine motor, rotates basket. In high speed ring gear is free and spider which carries planet gear is clutched directly to high speed pinion, clutch having been engaged by thrust spring. When solenoid is de-energized, the shifting ring moves axially, because of roller in slot, bringing braking surface in contact with ring gear flange, and disengaging the high speed cone clutch. Braking slows basket to 52 r.p.m., obtained by pinion driving planet gear which turns spider around common center, while internal ring gear is stationary.



High speed operation for drying, 500 r.p.m., can only be obtained when solenoid circuit is energized by the program timer. Similarly the drain pump operates only when idler pulley, solenoid-actuated, forces V-belt over against pulley. Since hose discharges at a point above the normal water level in the tub, gravity draining is prevented thus eliminating need for valves in drain system. Complete planetary drive assembly runs in bath of S.A.E. 20 oil. Front of housing is cast iron, rear is drawn steel.


Frictional damper
Drawn vanes
Welded steel basket
Double seal
Planetary transmission
Aluminum ring supports seal
V-belt drive
Steel clamping ring holds two drawn steel halves of outer tub watertight
Aluminum ring bolted and gasketed to transmission housing by six bolts threaded into blind holes

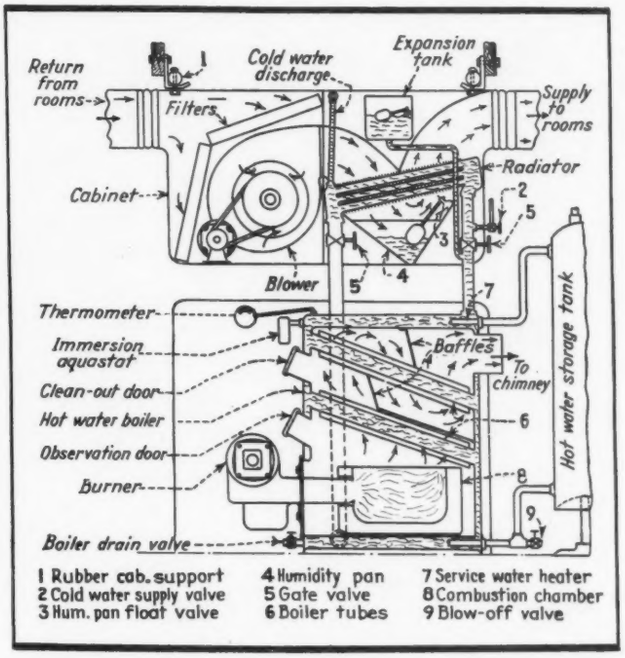
Two vitreous-enameled drawn steel halves of the outer tub are assembled with a molded rubber gasket between and a steel clamp ring drawn down over the flanges.

The basket in which clothes are washed, rinsed and dried is drawn of heavy-gage steel, welded into a one-piece body, porcelain enamel finished. Four deep vanes, drawn into sides, and a domed bottom are designed for strength and rigidity. Perforations in wall (960 holes, 7/32 in. diameter) are countersunk.

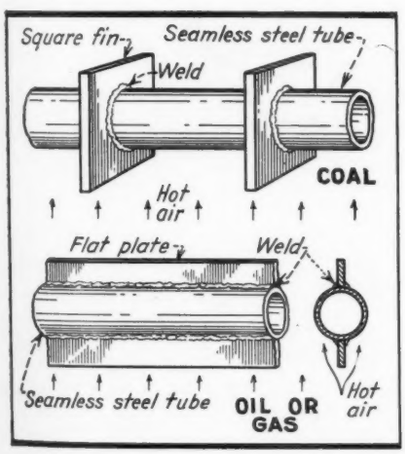
Two seal glands, one of which is held in place by an aluminum ring and the other pressed directly into the front housing, are placed between outer tub and drive. Gaskets are also placed on either side of the outer tub. Hub socket, which receives the drive sleeve, is welded through two diaphragm plates, which in turn, are welded around their outer circumference to shoulders on the basket. A heavy drive pin within this socket mates with the slots in the drive sleeve.

Heater Does Triple Duty

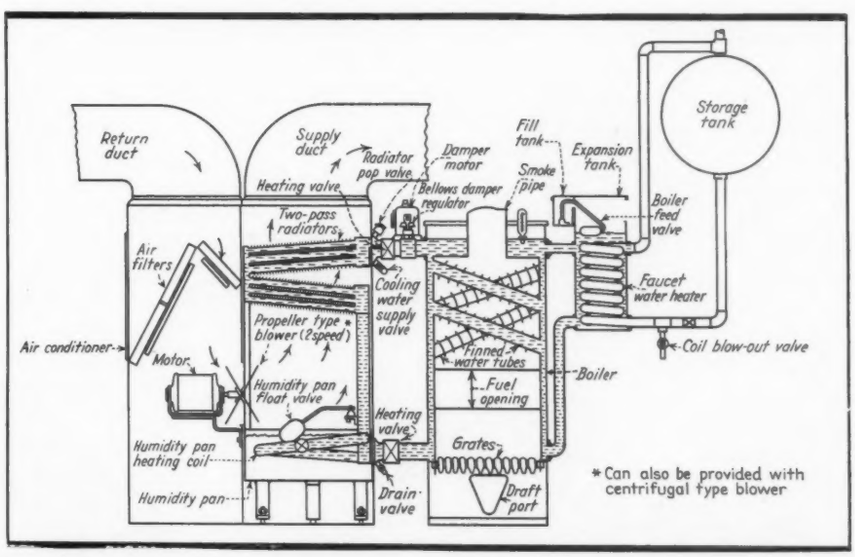
Indirect heating arrangement in Allis-Chalmers home conditioner makes the same unit available for winter heating, summer cooling, and for year-round hot water supply. Smallest size, shown above, is rated at 70,000 BTU when using either oil or gas burner. Lower cabinet containing burner and boiler is connected by circulating pipes to heat dissipating radiator in upper cabinet. Suspending upper unit from ceiling simplifies duct connections, reduces floor space required.



Cold air is drawn from rooms through spun glass filter by centrifugal blower and circulated through radiator twice by baffles. For summer cooling, gate valves are closed and city tap water continuously passed through radiator. Double pass of air through radiator gives maximum cooling for minimum amount of water. Air is dehumidified by condensation of moisture on radiator. Hot water is provided by copper coil placed in boiler as shown. Baffles are of chrome or silicon steel.

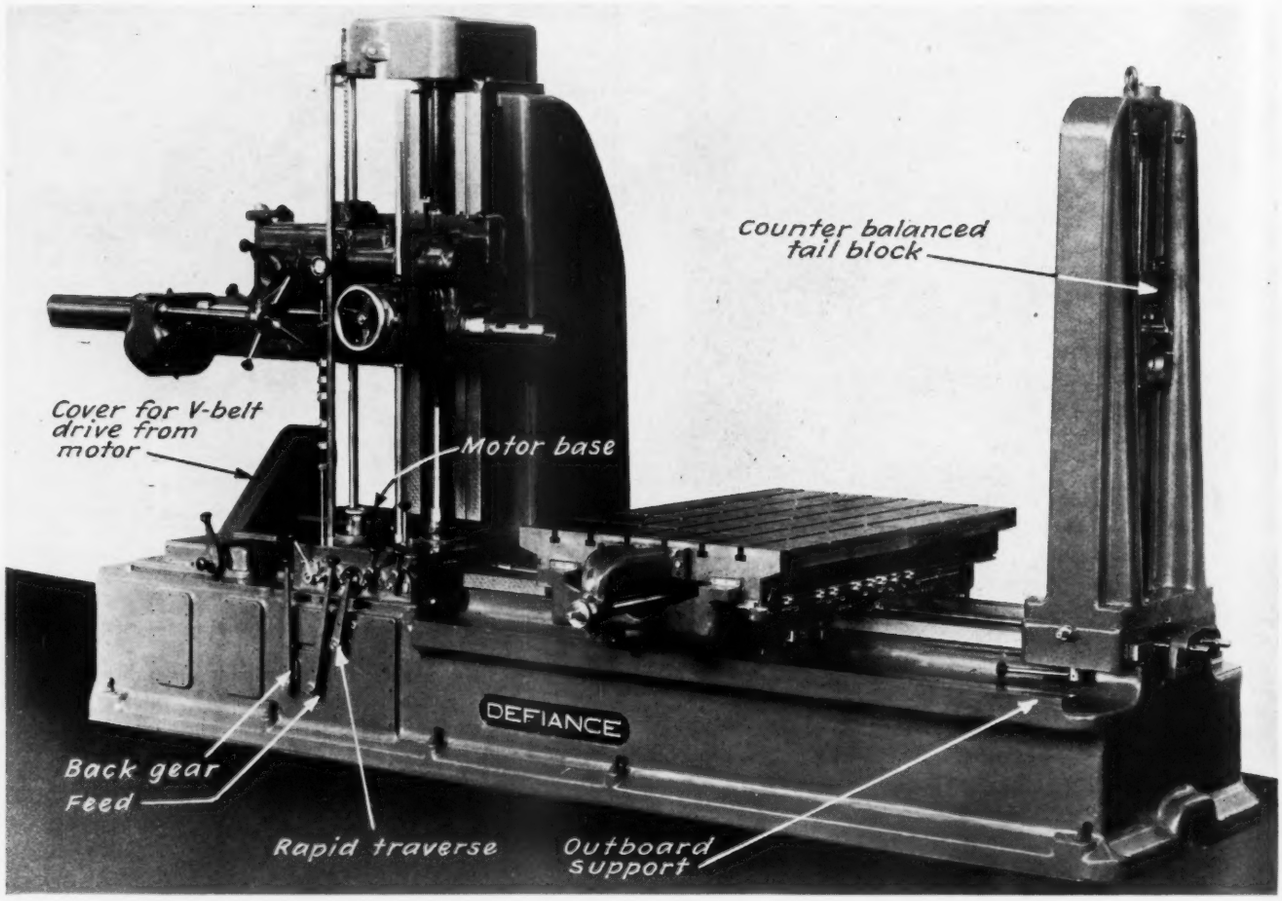


Relatively thin seamless steel tubes form the boiler surface of the heating units. These are finned to increase surface area exposed to heat. In the coal fired units, square steel stampings welded to the round tube make satisfactory fins because the dry soot can be removed easily. In oil or gas fired units continuous fins stamped from flat plate are welded along the length of tube keep air flow smooth and make removal of oily soot easy.

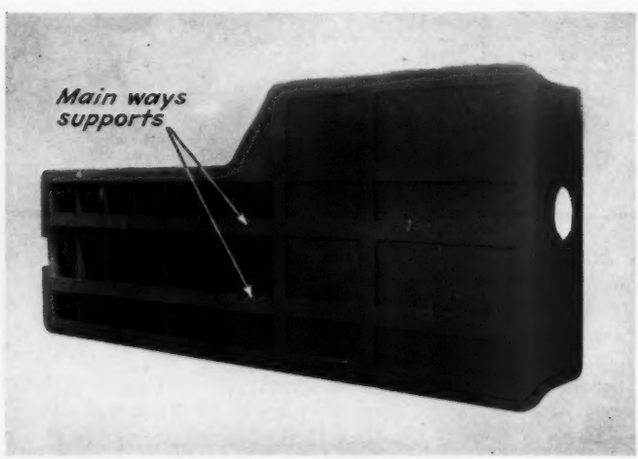


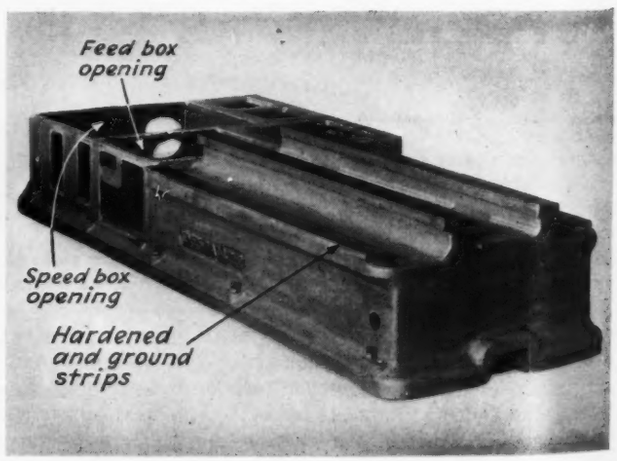
Similar principle is used in coal fired units (80,000 and 100,000 BTU) which are equipped with gravity feed hopper. Tubular type boilers, which require a comparatively small amount of water, are used. Temperature of water is kept constant with aquastat control while room temperatures are maintained by thermometer control of blower operation. Either large blade low velocity fan or centrifugal blower is used depending on heating capacity of the furnace. Humidity pan heating coil is regulated to give correct moisture automatically. Draft opening is V-shaped and slide is adjustable to desired proportion of air.

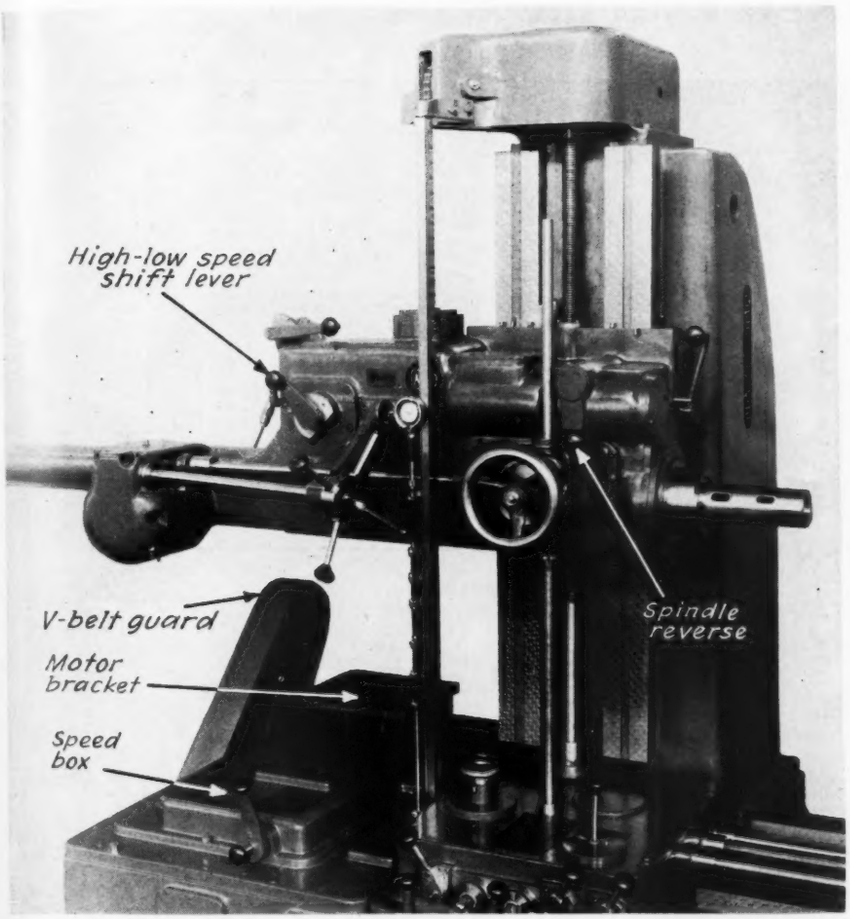
MODERN DESIGNS – Integral Castings for Strength



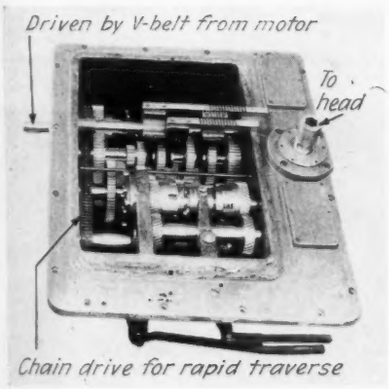
Outboard table supports are cast integral with the bed of Defiance horizontal boring mills, leaving only 3 in. overhang at each end of the table on the larger machines. Bed, column, back rest, head, saddle, speed and feed boxes are semi-steel castings, A.S.T.M. No. 35 iron containing 30 percent steel and 1 percent nickel. Table casting contains Mayari iron, chromium content of which gives hard close grained surface capable of sustaining a fine polish. Bed casting is ribbed as shown with supports for the two main bed ways. Hardened and ground wear strips are used for outboard bearings. Way surfaces are hand scraped and protected by scrapers and felt oil seals. Openings at wider end of bed castings are for speed and feed gear boxes. Tail block, boring bar support, slides on vee ways. Tail block is balanced by equal weights in each side of the column. Counter balanced spindle head unit is hand-scraped for a precision bearing with column; it is clamped between dovetail way and front edge of column ways. Low speed for large diameter milling and boring is obtained through an additional unit which drives a large gear on the front end of the spindle sleeve, thus reducing heavy torsional loads. Spindle center line clearance is 1⅞ in. in low speed.



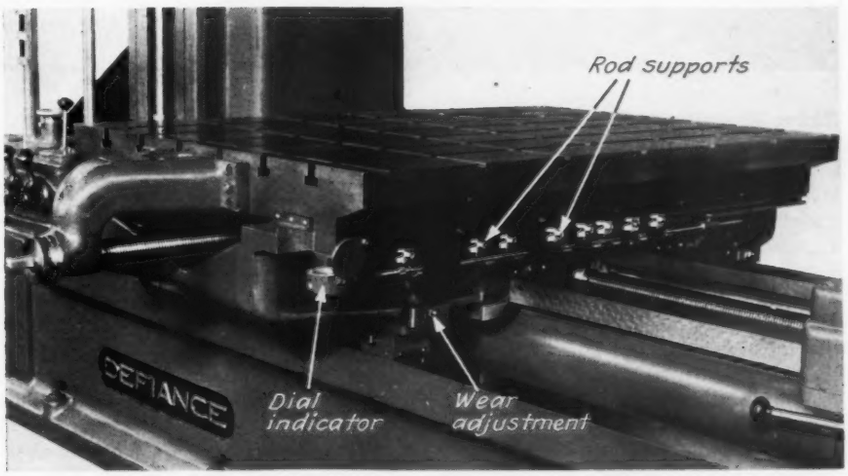




Heat-treated and forged spindle sleeve, Timken bearing-mounted, slides in cast iron bushings front and rear. Bearings are zero precision, two single 8½ in. O.D. at front and one double 7½ in. O. D. at rear end. Close fit is achieved by heating bearings in oil before assembly and letting them cool in place. Main spindle drive is designed to provide high-speed range of 20 speeds from 12 to 1,000 r.p.m. and with low-speed unit 20 speeds from 4 to 320 r.p.m. Six-splined, heat-treated S.A.E. 4140 shaft from speed box passing through hard bronze gear drives the head unit. Upper end of speed shaft is supported by bearing in bracket at top of head column. Spindle can be reversed without reversing feed. Spindle feed is through vertical shaft from feed gear box. Twelve feeds range from 0.0016 to 0.490 in. per revolution at high-speed setting to 0.0047 to 1.524 in. with low-speed arrangement. Power comes to the first sliding gear splined shaft through a safety clutch in speed box. This shaft carries two sets of two cluster gears controlled by two interlocking levers at right end of box. Second sliding gear splined shaft carries one cluster of three gears controlled by vertical lever at right-hand corner of box. Fast travel is transmitted through flexible coupling. Fast travel and feed levers are interlocked so that both cannot be engaged at the same time.

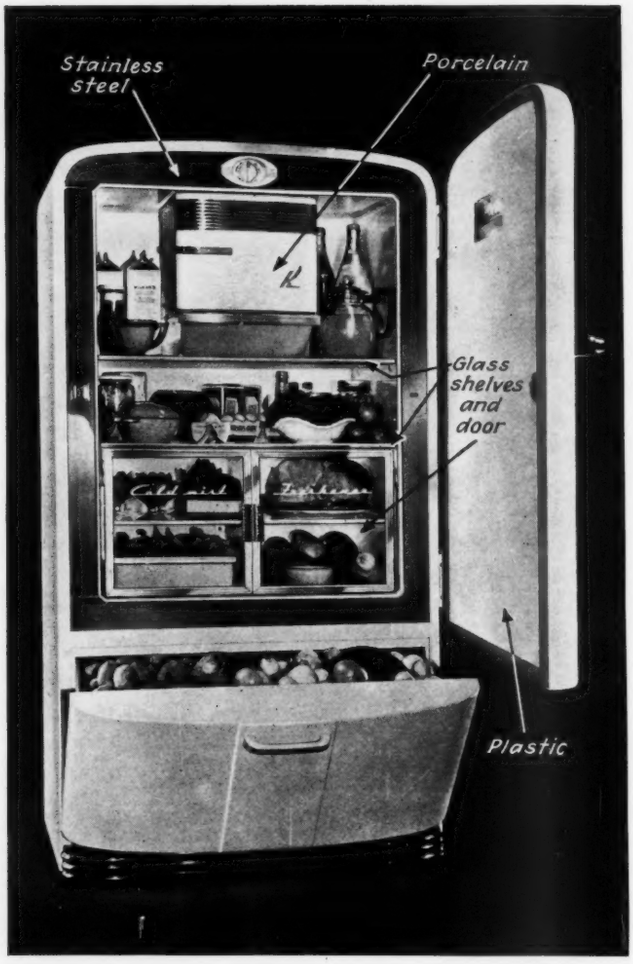


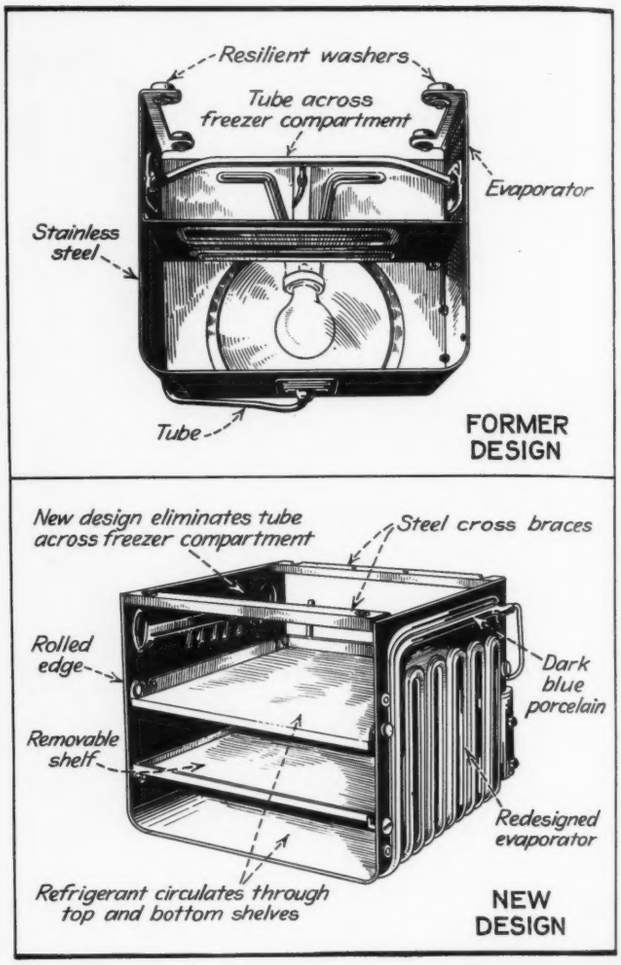
V-belt is used between 7½ hp., 1,200 r.p.m., motor and speed-box. Main clutch is a double Twin-Disc type running at a speed of 450 r.p.m. Clutch shaft drives lubricating pump and chain drive to rapid traverse shaft. The positive six-jaw double feed clutch for feeding in both directions is broached to fit six-splined clutch shaft. Rapid traverse double Twin-Disc clutch disengages on release of pressure from the operating lever. Direction of lever motion controls direction of rapid traverse. Vertical drive shaft to head is driven by bevel gear. This alloy steel shaft drives hard bronze gear in head.



Saddle is guided on inside edge of bed ways and is gibbed to bed by a square lock method. Outboard bearings with tapered gibs allow adjustment for wear. The two ways supporting the plates are cast in one piece for rigidity. Table has cross travel equal to its length and when clamped is held against front guide ways. Center line of spindle travels to ⅛ in. below level of table top. Bed, saddle and table ways and head ways are lubricated by a central system and head unit is automatically lubricated by pump. All shafts and gears are made of S.A.E. 4140 heat-treated steel. All gears are 8/10 pitch. Table is constructed to take dial indicators. Feed can be disengaged at any point and is automatically disengaged when the extreme limit of travel is reached. The fine hand feed on the spindle has a dial graduated in thousandths. All helical gears in head drive are shaved for precision. Clutch in speed box is accessible for adjustment and can be removed without disturbing other elements.

MODERN DESIGNS – New Uses for Materials





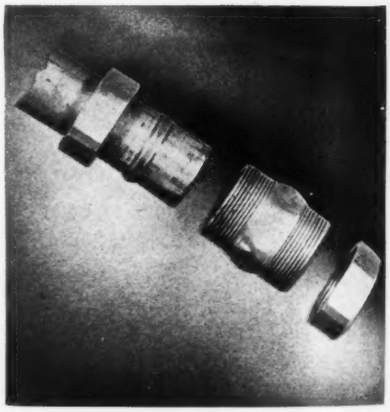
Priorities on metals have particularly affected the home appliance industry, large user of aluminum and stainless steel. Shortage of these two materials has resulted in their being replaced by plastics, low-cost steels or cast iron coated with vitreous enamel and other less restricted materials. Many changes are still on the drawing board or just getting into production. Kelvinator early this year replaced its stainless steel evaporator door with one of porcelain finished steel, stainless steel trimmed. Also, the inside panel of the refrigerator door is now made of laminated plastic. White surface is baked on, giving extra cure to the plastic to eliminate possibility of fading or yellowing.

More recent change by Kelvinator was to replace stainless steel evaporator with one of porcelain enameled steel. Design was changed eliminating cross tube to header in each wall of previous model evaporator. In new design refrigerant enters top shelf, passes through right wall, through bottom shelf to left wall.

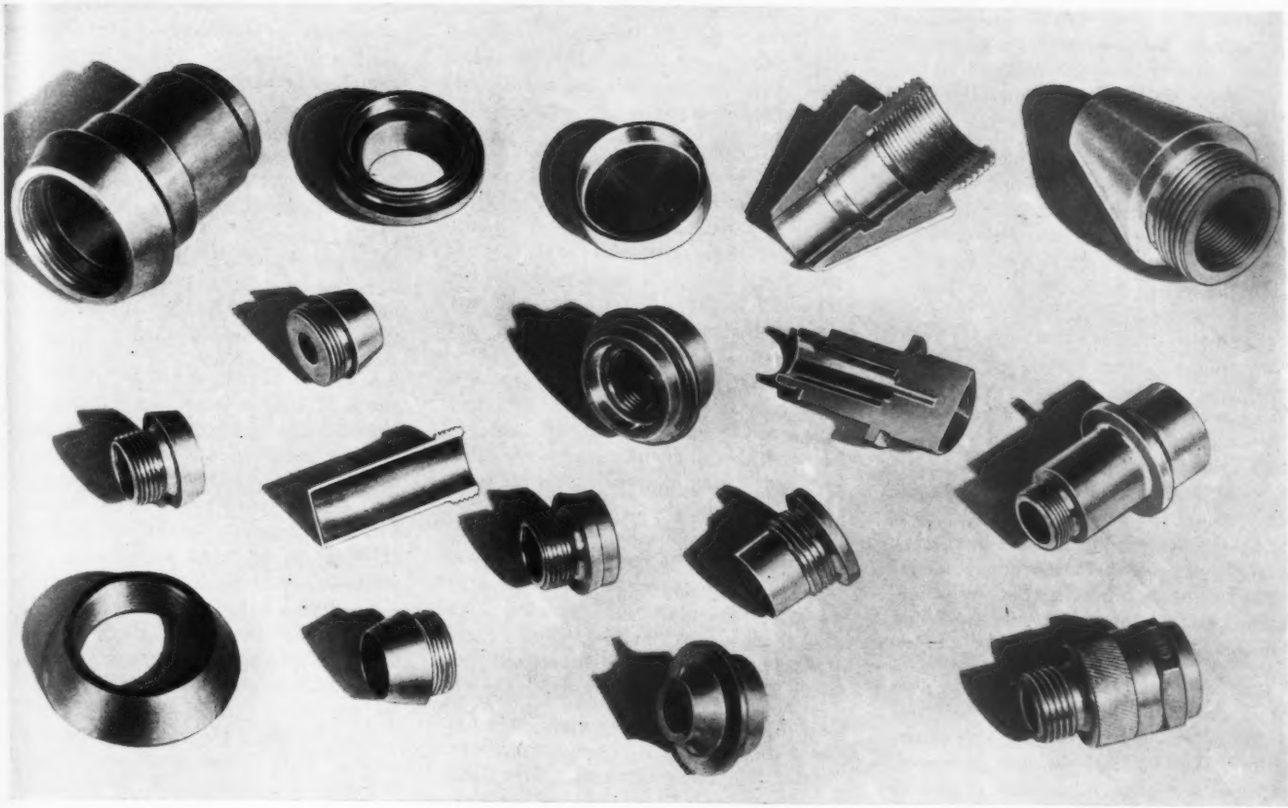
Aluminum ice trays, now limited to two in refrigerators of 6-10 ft. capacity, have been replaced by tinned copper trays with rubber grids. Rubber is treated to eliminate tarnishing of tinned surface. Co-efficients of thermal conductivity of the metals are: copper, 2,680; aluminum, 1,380; tin, 440. Experiments are still under way on steel and porcelain trays.

Glass shelves, in service for the second year, require steel only for framing. By leaving a space between back of box and edge of shelves cold air circulation is good. The glass shelves are also easy to clean.

Door is sealed by "balloon-type," live-rubber seal. A stainless steel band frames the door opening and is designed to eliminate projecting screw-heads. Box has welded one-piece sides and top cabinet, rust-proofed and baked enamel finish. Interior box is one-piece porcelain with rounded corners and acid-resistant bottom. Refrigerating unit is spring and rubber mounted in steel housing. Secondary cooling coils are in the walls of the "Freshener."



Coupling for electrical conduit made from short lengths of welded steel tubing is being used by one manufacturer as an alternate material for comparatively heavy cast pipe couplings. The male portion of the coupling is formed from 1½-in. length of 1⅛ in. diameter —15 gage welded steel tube. The central section is expanded to a 1¼ in. maximum outside diameter and then pressed to hex shape.



Screw machine products turned from steel, brass or aluminum bar stock. Shapes could be duplicated by die-casting in non-ferrous alloys, but for most pieces not with equal economy. If die-cast, supplementary machining would be required on some parts

DIE-CAST PRODUCT OR SCREW MACHINE PRODUCT – II

HERBERT CHASE

IN THE first installment of this article, which appeared in the June number of PRODUCT ENGINEERING, consideration was given to factors that involved materials and their properties. In this part of the article, factors will be discussed that are closely associated with production technique.

DIMENSIONAL ACCURACY. In general, if a comparison be made between the casting "as-cast" and the screw machine product, the latter has a slight edge over the die-casting in respect to the tolerances which can be held. If, however, the die-casting be machined it can be held within the same dimensional limits as the screw machine product. Between points formed in solid integral parts of the die, the usual "as-cast" limits on die-castings in zinc alloy are plus or minus 0.001 in. per in. plus whatever drafts are required. If, however, the measurement be across a parting line or is affected by clearances in die-parts having relative motion, plus or minus 0.003 or 0.004 in. is commonly allowed in addition to the foregoing tolerance. The limits are slightly wider for aluminum and for magnesium alloys, and somewhat wider still for alloys based on copper. There is, of course, a chance for further variations at the parting line unless the flash formed be trimmed or machined with considerable accuracy.

On screw machine products, the general commercial practice is to hold diametral dimensions when marked in decimals to within plus or minus tolerance of 0.002 or 0.0025 in., and within plus or minus 0.003 in. on lengths unless closer dimensions be specified. If specified, diameters can be held to plus or minus 0.001 or even 0.0005 in. but this requires extra expense. Drafts needed on die-castings are not required on screw machine products, although machining is facilitated if shoulders are tapered rather than square.

SURFACE SMOOTHNESS. Tool marks, usually left by roughing cuts on screw machine products, can be removed by shaving, skiving or burnishing. Die-castings as cast in most alloys can have, when required, surfaces so smooth that they take a high buffed polish. Both

die-castings and screw machine products can be produced with surfaces that require little polishing and only moderate buffing in preparation for plating.

APPEARANCE involves so many factors, some of which are intangible, that general conclusions are not easy to make and may be of doubtful value. Most screw machine products have considerable luster whereas the die-casting is usually frosted. Both types of products tarnish after a time when exposed to the atmosphere. Other factors such as corrosion in service, and especially the rusting of steel, affect appearance often in a marked degree, but comparisons in this regard do not permit of satisfactory generalization. Shapes such as are here compared may be identical, but it is possible to produce in the die-casting certain variations in surface contours usually not feasible in the screw machine product that may have a marked effect upon appearance.

COSTS OF APPLIED FINISHES are, in general, about the same for the two types of parts, but may favor the screw machine product slightly in some instances, especially when an unusually smooth surface is needed as for plating, or when considerable grinding is required to remove marks at parting lines on the die-casting. Die-castings are sometimes subject to slight surface porosity and often to some sub-surface porosity which may cause trouble in finishing, especially if high-temperature baking is required. With proper care in casting and in die construction, as well as in selection of finishing materials and baking schedules such difficulties can be overcome.

PRODUCTION RATES for the die-casting are likely to exceed considerably those for the screw machine product. For small parts, similar to those produced by screw machines in general, the die-casting machine for zinc alloys runs about 200 to 300 cycles an hour minimum with some machines running up to or exceeding 1,000 cycles an hour. Moreover, especially if total requirements are large, the die frequently has several cavities. In machines equipped for using unit dies, several dies can be run simultaneously. The machine cycles cited apply to zinc alloy in particular, the rate may be cut to one-third or one-fourth for alloys of higher melting point. It should be noted, however, that the rates given are for casting only and do not include fin removal or any machining, both of which involve separate operations after casting.

Rates of screw machines vary from about 30 to about 3,600 pieces per hour per machine, depending upon the size of piece, type of material used, number of spindles, and also upon the number and character of operations required. Often the piece is completely finished and ready for use, but for some parts secondary operations are required.

TOOLING COSTS are likely to be higher for the die-casting than for the screw machine product, partly because it is necessary to make a die and usually tools for flash removal. For the screw machine product it is possible to use standard tools; when special ones are needed their cost is likely to be less than that of the die required for casting, although there may be exceptions, especially if special cams for actuating the screw machine tools are needed. Considerable time and expense are often involved in keeping screw machine tools sharp, and also in the maintenance of dies and trim tools for the die-casting. For the most used zinc alloys the maintenance on dies which are properly made is low, even for long runs; for alloys of higher melting point, especially for brass, the cost of die maintenance increases considerably.

LABOR COST is generally higher for the die-casting because die-casting machines are not completely automatic, also flash must be trimmed and often other machine work must be done on each piece. Although the screw machine is fully automatic, some attention is required to check parts as to size and finish and when adjustments must be made expert set-up men are needed. Set-up time averages about 4 to 8 hours on multiple-spindle screw machines and around 2½ hours for single-spindle machines. Die changing on most casting machines does not require labor so highly skilled as for screw machine set-up. Casting die changing ranges from about ½ to perhaps 4 hours with the average around 2 hours for dies of the size needed to make parts such as the screw machine commonly turns out. For the die-casting extra time is required, as a rule, to set-up trim dies in a punch or arbor press. Special set-ups in other machines may also be needed for either die-cast or screw machine products if secondary operations are required.

MATERIAL COSTS generally favor the screw machine product provided soft steel rod or other low cost steel rod can be employed and that the loss in scrap is low. If seamless steel tubing, special alloy steels, or non-ferrous metals are required for the screw machine product, material costs are likely to favor the die-casting. Ingots for castings are lower in cost than corresponding non-ferrous wrought alloys.

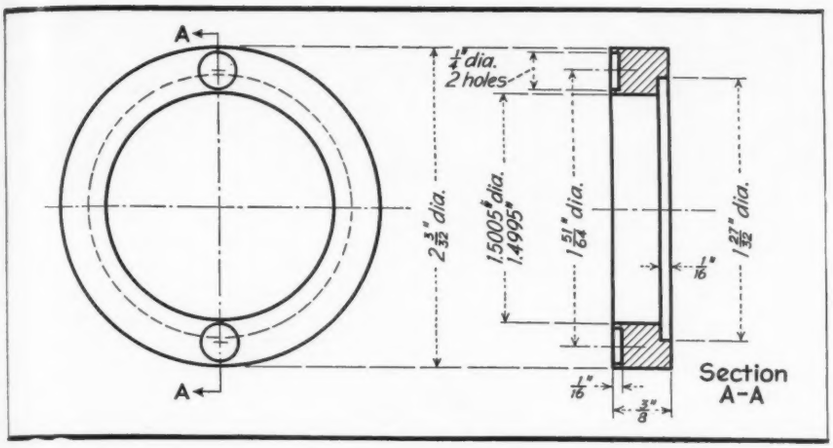
WASTE IN SCRAP is lower with the die-casting than for the screw machine product because the former is produced close to actual size, with holes cored and with diameters as required. Gates, sprues, flash and chips, as well as rejects are remelted and reused without substantial loss. Whether bars or tubes be used for the screw machine product, considerable metal is usually machined away. Steel scrap has a low value or none at all. Non-ferrous scrap sometimes brings about one-third of the cost of the wrought material. Although scrap salvage may pay for the cost of machining on the piece, the loss is still an important factor in over-all cost.

MACHINING COSTS for either product depend, of course, upon the number and character of operations needed to meet specific requirements. Machining, however, always represents a considerable part of the cost of the screw machine product. Primary operations, however, are done rapidly and at low cost. Secondary operations may cost as much or more than on the die-casting. Die-castings, on the other hand, always require flash removal and often machine operations done on the part increase the cost considerably.

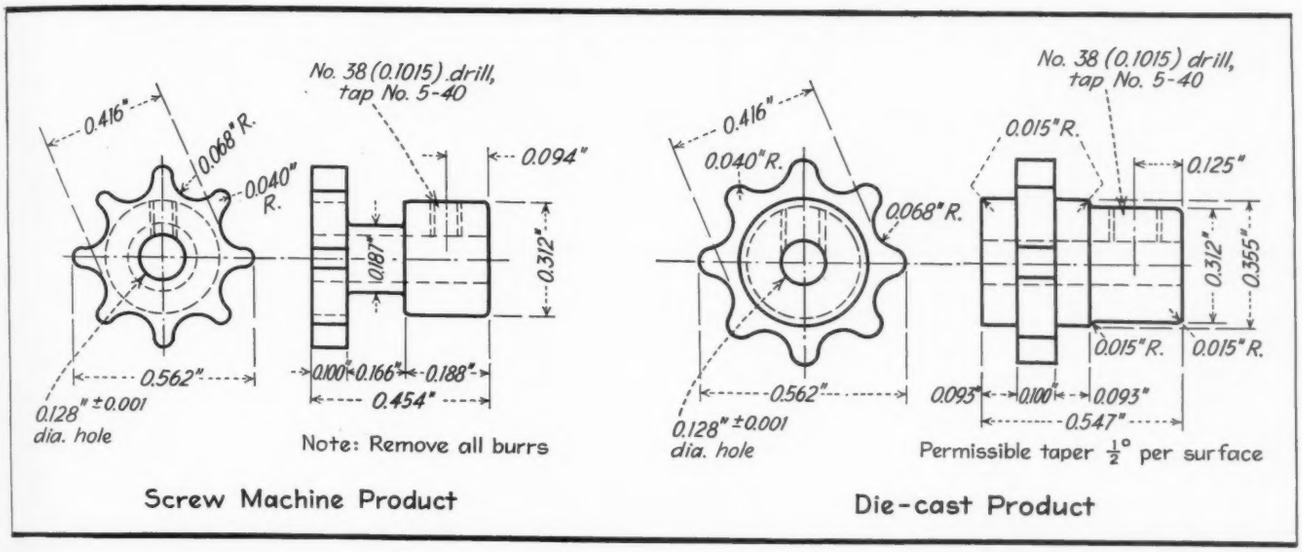
Zinc alloys and magnesium alloys used in die-castings machine as freely as brass in wrought form. Some aluminum alloys also machine freely, but others are intermediate in machining properties, as are some die-cast brasses. Certain brass die-castings are rather hard to machine. In general, the differences in machining properties of die-castings and of non-ferrous wrought materials are slight, but for average pieces die-castings machine more freely than the ferrous materials used for screw machine products.

CONCLUSION. Many factors should be weighed in arriving at a choice as between die-castings and screw machine products. Specific requirements often bar the use of one or the other. However, when either can be used, prices should be secured on both and then the one selected which promises to meet general requirements best. Study of the accompanying specific examples may provide some indications as to the weight to be assigned to the various factors.

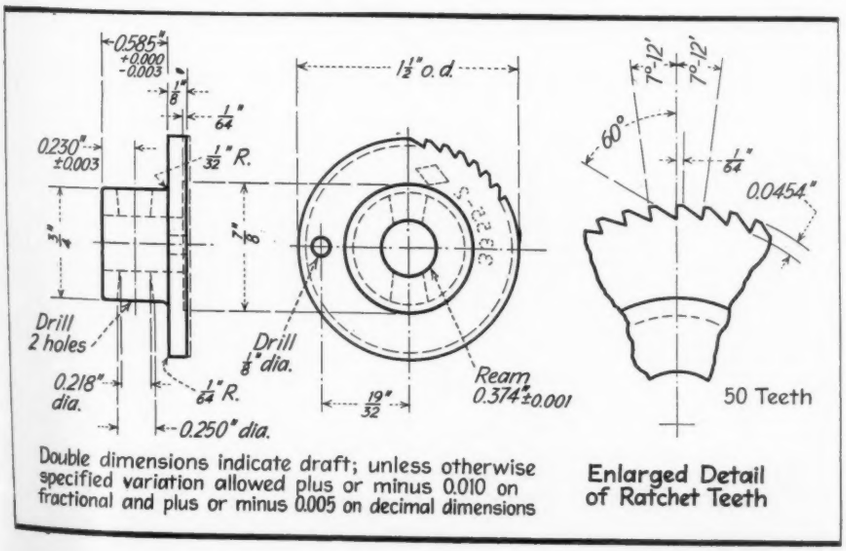
Existing conditions in the metal working industry have prevented the author from securing more specific or an equal number of examples giving comparative costs favorable respectively to the screw machine product and to the die-casting. If accompanying examples appear more favorable to the die-casting than to the screw machine product, this is a coincidence and not intended since repeated, though unfruitful, efforts were made to secure examples in which costs are more favorable to the screw machine product than are those in the examples cited.



Threaded retainer ring with holes for spanner wrench was initially produced on a screw machine at a cost of 18 cents per piece; no data as to material used or tooling cost is obtainable. The ring is now die-cast in lots of 1,000 at a cost of 3.5 cents per piece. The two-cavity die used cost $98. On the die-cast part, a 16-pitch thread is cut on the outside diameter at a cost of 1.5 cents per piece, making the total cost 5 cents per piece. No other machining is needed. Neither the die-casting nor the screw machine product requires an applied finish. The chief advantage claimed for the die-casting is its lower cost.



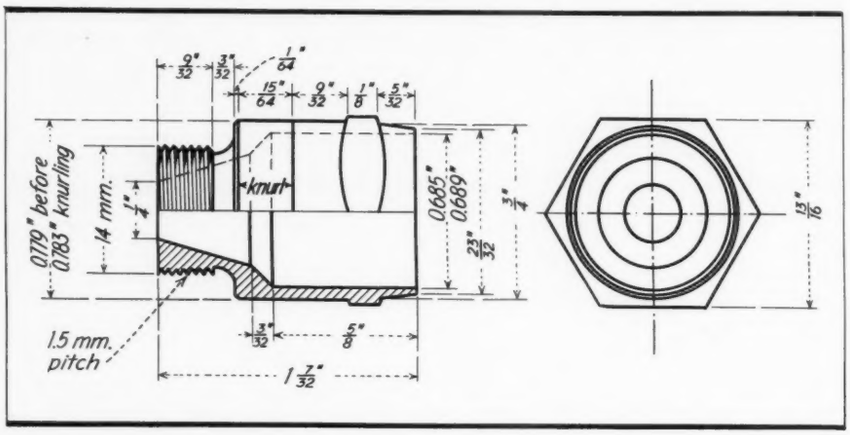
Sprocket with hub originally produced by screw machine from brass pinion rod in lots of 33,000 at a cost of 1.7 cents per piece, of which 1 cent represented the cost of material. Nickel plating cost 4 cents per pound. When redesigned to avoid the undercut neck, the piece was die-cast in zinc alloy, using a two-cavity die costing $205. Piece cost was thereby reduced to 0.7 cents; black nickel plating is applied costing 2 cents per pound. Redesign saved $100 on the first order for 33,000, besides paying for the die, and $300 on each subsequent reorder. Drilling and tapping of setscrew hole in hub is understood to have been included in the cost figures given above.



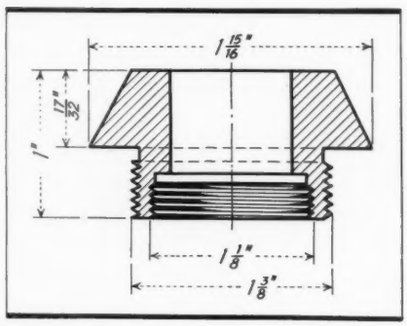
Ratchet wheel with hub is produced in die-cast form from zinc alloy in lots of 10,000, the piece price including all machining required being 3.9 cents, the weight being 1.04 oz. Production is in a six-cavity die, five of the cavities being for other small parts of the same machine, produced simultaneously. An estimate, made by the screw machine department of the same company which produces the die-cast part, of the cost of manufacture by screw machine from free machining steel costing approximately 4 cents per lb., in lots of 5,000 is 10.3 cents each. This includes supplementary drilling operations and gang milling of teeth. In the die-casting the teeth are formed in the casting operation, but flash has to be removed.

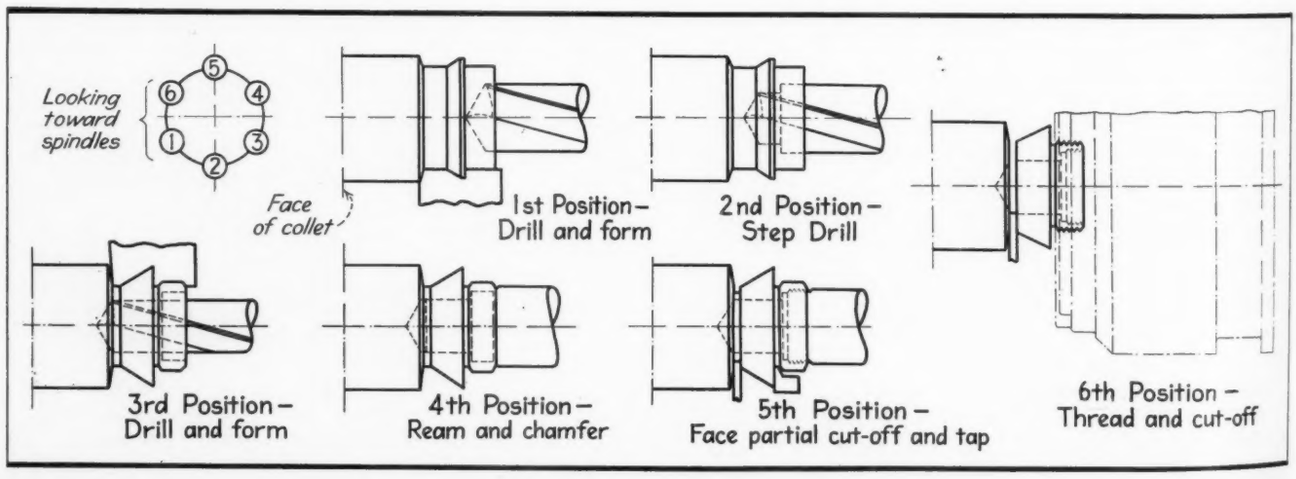
(*Continued on next page*)

Spark plug shell of standard 14-mm. size is produced from S.A.E. X1112 steel 13/16-in. hex bar stock, costing 4.5 cents per pound, in multiple-spindle automatic screw machines at the rate of 900 pieces an hour. In lots of 10,000 the cost is 3.75 cents per piece, and the application of a blued finish costs $1.25 per 1,000 pieces extra, making the total cost 3.87 cents per piece. If tooling cost, which is $50, be added the total cost in lots of 10,000 is 4.37 cents per piece. A die-caster estimates that this shell, produced in S.A.E. 903 zinc alloy costing 10.25 cents per pound, will cost 2.5 cents per piece in lots of 10,000, without an applied finish. Die-casting would be done at the rate of about 500 pieces an hour using a two-cavity die estimated to cost $255. The piece price includes removing the flash and chasing the thread as supplementary operations. Total cost, including die cost, for 10,000 die-cast shells is thus 5.05 cents per piece. If, in both types of part, piece cost remains unchanged and lots of 100,000 were required, the total cost, including tooling, would be 2.75 cents per piece for the die-cast shell and 3.92 cents per piece for a shell produced on the screw machine. The screw machine product would be stronger and probably slightly smoother, and would also withstand higher temperatures in service. Spark plugs with die-cast shells, however, have been used successfully at least on an experimental scale in water-cooled engines. Although the steel shell weighs 7/8 ounce in finished form, it requires 3½ ounces of hex steel rod costing 0.983 cents to produce it, no allowance being made for a small credit for scrap recovery. As against this, the die-cast shell would require ¾ ounce of zinc alloy, costing 0.481 cents, with scrap loss substantially nil. Thus, although the steel costs less than half as much per pound as the zinc alloy, the larger amount of steel required brings the material cost per piece to more than double that for the die-cast piece.

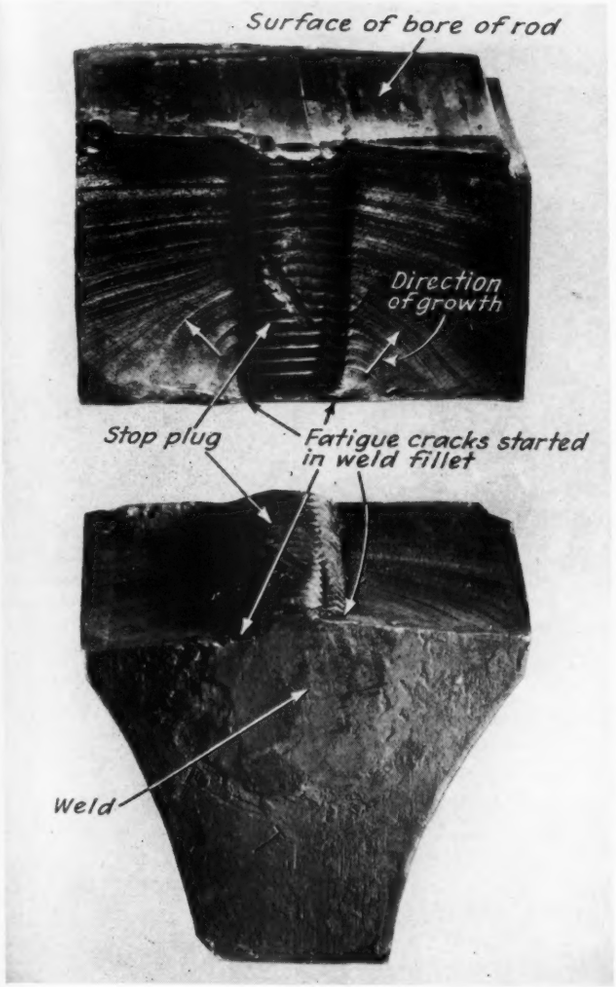


Hollow tapered plug produced in a multi-spindle screw machine from S.A.E. X1112 steel bar, costing 4.5 cents per pound, at a net cost of 7.76 cents per piece in lots of 100,000, or 10.52 cents per piece in lots of 10,000. The piece is finished in one cycle of the machine except for removing the burr thrown into the hole by cut-off tool, which requires a supplementary operation included in the stated cost. Data on tooling cost is not given, but if a figure of $50 be set arbitrarily, the total cost including tooling would be 7.81 cents per piece in lots of 100,000 and 11.02 cents per piece in lots of 10,000. Including an allowance of 1/8 in. of metal for cut-off, approximately 0.95 pound of steel per piece is required. A die-caster gives the following estimate on producing this piece from zinc alloy costing 10.25 cents per pound, the approximate net weight per piece being 0.30 pound, making the material cost slightly lower than for the steel used in making the screw machine product. The piece price, presumably including profit, is 7.0 cents per piece in lots of 10,000 and 6.75 cents in lots of 100,000. The charge for a two-cavity die for casting this piece is $295, making the total cost, tooling included, 9.95 cents per piece in lots of 10,000 and 7.045 cents per piece in lots of 100,000. Included in this price is the cost of cutting the recess back of the thread and facing the adjacent shoulder as well as chasing the external thread and tapping the internal thread for Class 2 fits. Machined surfaces would be as smooth as for the screw machine product, but other surfaces would have a normal die-cast finish.

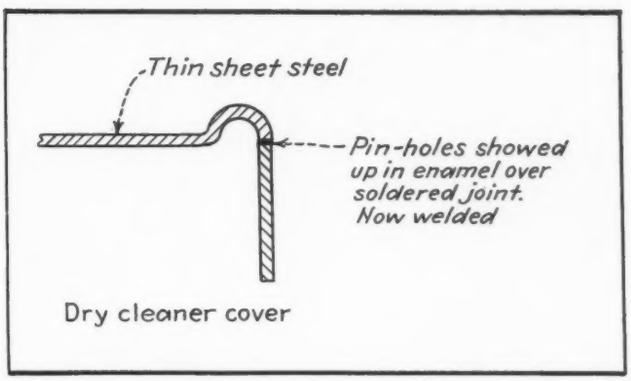



Looking toward spindles
Face of collet
1st Position – Drill and form
2nd Position – Step Drill
3rd Position – Drill and form
4th Position – Ream and chamfer
5th Position – Face partial cut-off and tap
6th Position – Thread and cut-off

Causes and Cures

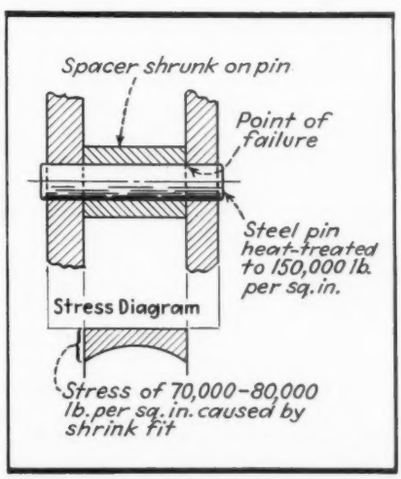


Forged side rod on a locomotive failed through fatigue cracks which started in the weld at one end of the stop-plug. The plug hole was drilled diagonally with the object of reducing concentrated stresses, but evidently there were highly concentrated stresses either within the weld or at the line of the first threads. The welding was done with an acetylene torch, which may have left residual stresses. To prevent failures of this kind, careful welding is necessary. Also, in drilling and tapping, the surfaces are left in a work-hardened condition, creating a starting point for fatigue cracks. This work-hardening should be removed by heating the surface up to 1,100 deg. F. Also avoid sharp edges.



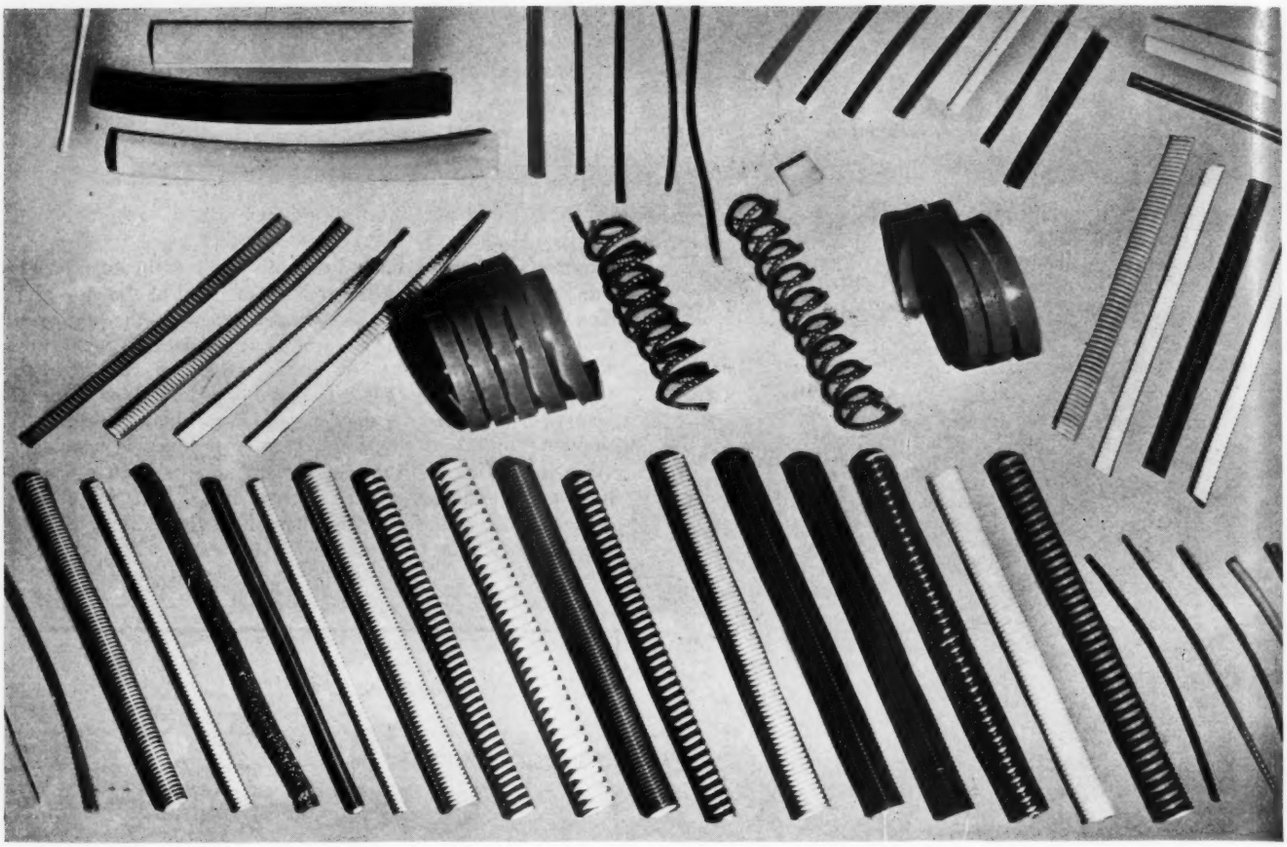
Thin sheet metal top rounded section of the cover for a dry cleaning washer was originally joined to the cylindrical side section by soldering. However, after the parts were enameled, pin holes showed up in the enamel along the full length of the seam. The flux used in the soldering job was causing the pin-holing, investigation disclosed. Since it was difficult to remove the flux without expensive procedure, seam welding was adopted for joining these two parts, and no more trouble was experienced.

Steel pin, used in a hinge joint, was heat-treated to 150,000 lb. per sq.in. and had a spacer shrunk on the center portion. The spacer was heated to about 800 deg. F., slipped over the pin and allowed to shrink in place. Failures began to occur in the pin at the end of the spacer even at nominal loads for which the pin was presumably over-strength. An analysis of the problem indicated that the shrink fit produced a peak stress of some 70,000 to 80,000 lb. per sq.in. in the pin at the end of the spacer thus reducing the assumed strength by half. This problem was solved by forging the pin and upsetting the center portion to get the desired spacer effect, then heat-treating the pin to 150,000 lb. per sq.in. tensile strength.


Spacer shrunk on pin
Point of failure
Steel pin heat-treated to 150,000 lb. per sq.in.
Stress Diagram
Stress of 70,000-80,000 lb. per sq.in. caused by shrink fit

BIGGEST PROBLEM in starting aircraft engines is not when cold, but rather when the engine is hot. One light engine manufacturer found a 6-volt battery adequate for laboratory tests, but it failed to start a hot engine in service. Little improvement resulted from mounting the battery near the starter so as to decrease voltage drop. Consequently, experiments were made with 8, 10 and 12-volt batteries. The 12-volt system finally adopted gave positive cranking even when the engine was too hot to operate properly after starting.

PRODUCT ENGINEERING will pay a minimum of $3 for each example published in Causes and Cures. Where illustrations are necessary, include drawings, rough sketches or photographs.



Thermoplastic extrusions, some of which are helically coiled around forms, rods or wire by the Schwab and Frank process

EXTRUDED PLASTICS

New and Unusual Die-Formed Shapes

THE POSSIBILITY of shortages in metal strip has recently focused designers' attention on continuously extruded plastics. Although not new, the extrusion process has undergone considerable development in the past year. Shapes in almost any length, ranging from flat strips, rods, tubes to pieces of various cross-sections, are now available.

Almost any thermoplastic can be extruded provided proper equipment and technique is employed, but to date the principal materials extruded are cellulose acetate, cellulose acetate-butyrate, ethyl cellulose and vinyl acetate. Choice of material depends on equipment, service factors and cost.

With cellulose acetate it is possible to extrude strips from which blanks can be immediately stamped for subsequent swaging or fabrication as required. The particular advantage of the procedure is that the scrap from the strips can be granulated and fed again into the hopper of the extrusion machine, making the utility value of the material substantially 100 percent. Scrap from purchased plastic sheeting, on the other hand, has a market value representing only a fraction of original cost.

Cellulose acetate-butyrate absorbs about one-half as much moisture as that absorbed by cellulose acetate plastic. It contains less plasticizer for a given flow than does cellulose acetate material, thus providing superior dimensional stability of the extruded product, particularly under conditions of varying temperature and humidity.

Best results in extrusion are obtained with relatively hard flowing material; the harder the flow the quicker the set-up. The hardness of flow and the effectiveness of the cooling device will determine the concentricity of the extruded plastic tubing.

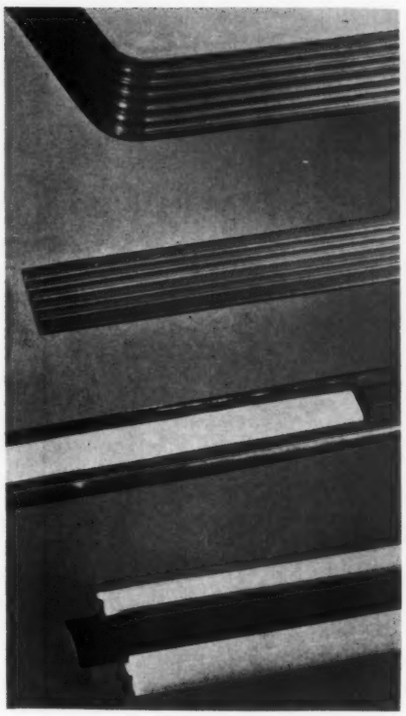
As the illustrations show, extruded shapes often have "tracks" of channel shape or C-shape to receive other parts. Rolled metal strips are sometimes applied after extruding to add strength and stiffness, to provide fastening means or to prevent warpage of the part in service.

Tracks can be on the exposed side of the strip to receive plated or polished metal or extruded plastic strips in a contrasting color. A great variety of decorative combinations can be secured

in this way. Another and promising application is the use of extruded plastic inserted in slots formed in rolled or extruded metal sections. The extruded plastic, being flexible, can be bent or shaped to various contours.

Fastening is done in various ways. In one type, a metal strip is held in an integral track on the back of the extruded plastic. The metal is punched to form prongs. Corresponding holes in the panel receive the prongs. An alternative is to provide threaded studs with flat elongated heads that fit the track. The studs can be slid along to conform to hole spacing. The elongated head prevents the stud from turning in the track. If the back of the panel is not accessible or a snap fastening is desired, spring clips made from wire are used in place of threaded studs. These clips spring outward after passing through the holes; they can be obtained in shapes which make possible removal of the extruded strip when the back of the panel is not accessible. See P.E. April 1941, page 211 for other typical fastening means.

All plastic extrusions have a smooth surface with a high polish precisely as if produced in a polished mold. Extrusions can be supplied cut to length or in continuous coils. Flat or slightly crowned strips supplied in rolls can be woven into highly decorative panels, chair seats, back rests, pedestal coverings and the like in one or more colors.



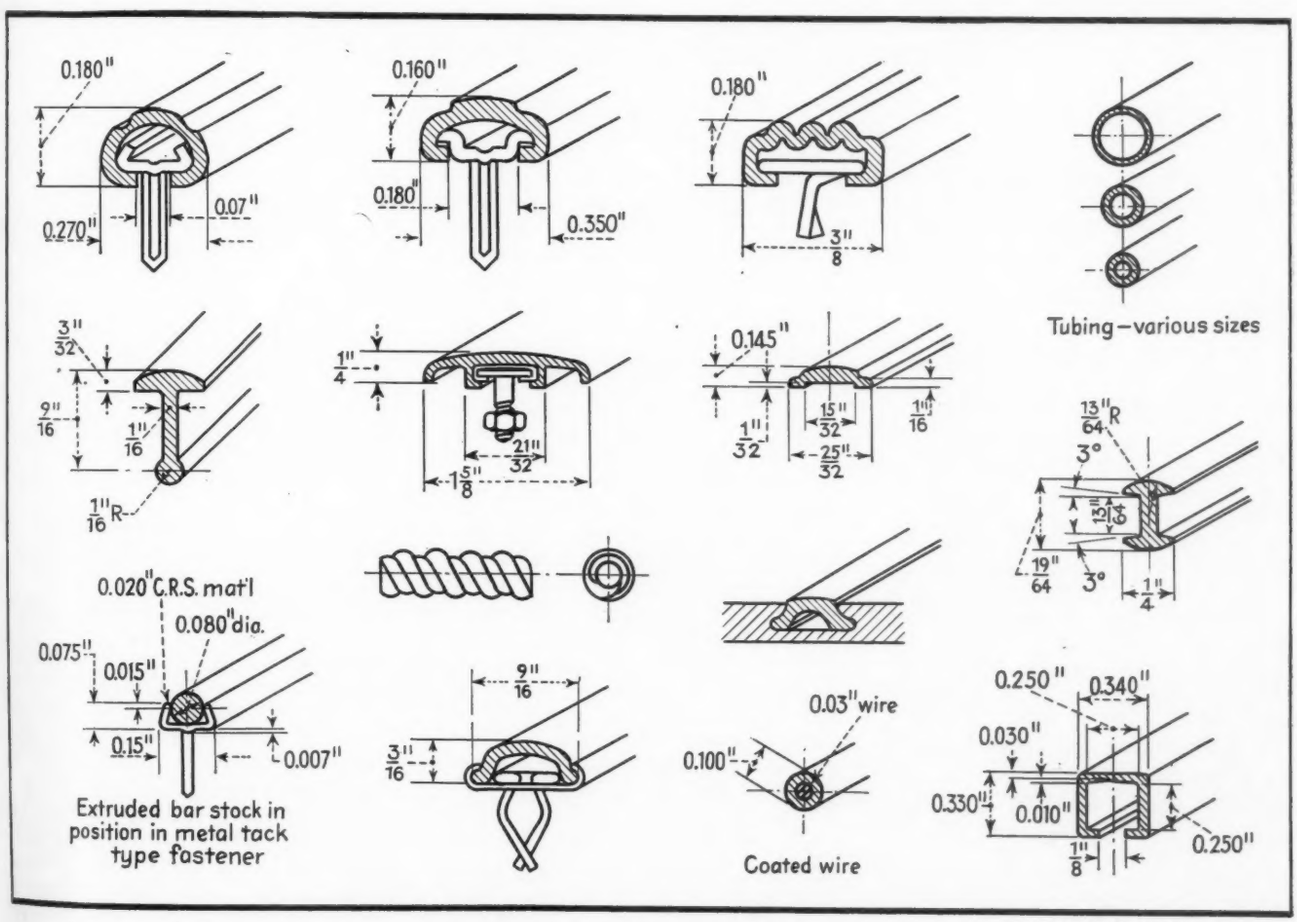
Tennessee Eastman Corporation

Extruded cellulose acetate butyrate table molding and decorative strips

Thin, narrow extrusions can be coiled around tubes or rods to give rope-like effects in one or more colors. Helical coils of this type are used on flexible insulated wires, such as telephone receiver leads, to prevent kinking and to protect against abrasion. Similar coils are useful over flexible or stiff tubing of metal, paper and the like, or over rods of any material in circular or other sections. If the plastic coil is transparent or translucent, the polished core shows through the plastic and adds sparkle and beauty to the assembly.

Extruded tubes have been recently used for a $\frac{3}{8}$ in. O.D. aircraft conduit. Since the tubing is transparent, the wires can be seen. The tube acts as an insulator, is easily bent for assembly and light in weight. In another application, transparent tubing is used in place of glass for soda syphons in bottles.

Another extruded product used for coil forms has a circular hole 0.015 in. in diameter and a three-point star-

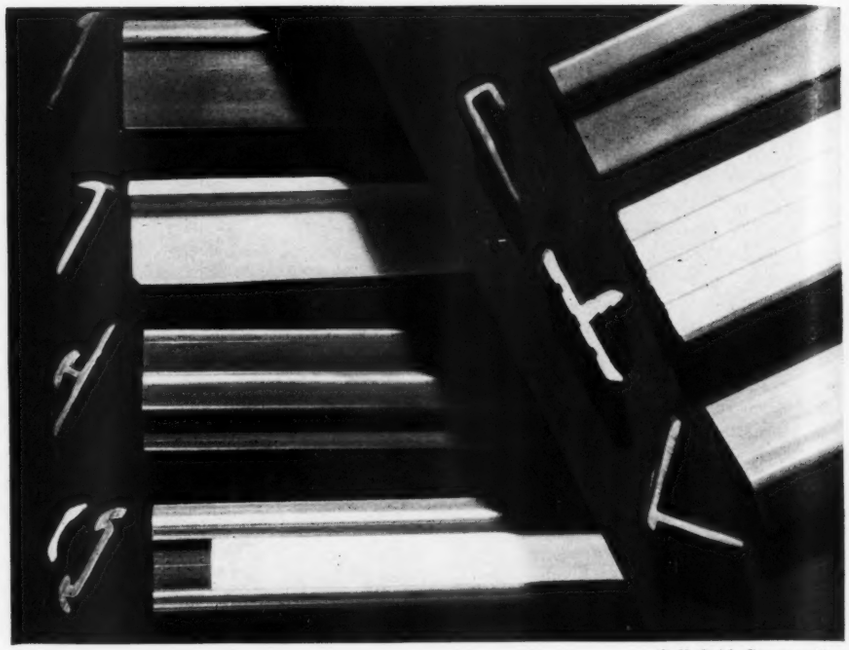


Detroit Macoid Corporation

Typical extruded plastic sections which are now available in almost any thermoplastic material

shaped exterior. One end of the coil wire is brought through the central hole and the remainder of the wire is wound on the edges or points of the star-shaped strip. Extruded plastic has also been applied over a wire central core, as is done in rubber-covered wire. In one case the material is opaque white to match the enamel of a refrigerator shell. The extrusion hides the joint between two curved sheet steel panels. After a length is pulled taut around the recess, the wire ends are bent inward to form hooks which hold the strip in place. Extruded T-shapes or others can be applied to hide joints in any panel assembly or to provide finished edges or decorations on many products where, heretofore, metal or wooden moldings usually have been applied.

Although extrusion requires the use of a die, such a die costs only a small fraction as much as does a mold for shaping plastic by press molding. Die cost depends on the size and shape of section to be extruded, and has ranged from $30 to $125 for most extrusions produced up to the present time.



Celluloid Corporation

Extruded moldings for panel joints suitable for walls, tables and cabinets. Material is cellulose acetate

Case Histories In Patent Law

H. A. TOULMIN, JR.

(EDITOR'S NOTE: *The purpose of these Case Histories is to give a better understanding of the patent law in the public interest. The author advises that actual cases should be submitted to your own patent attorney.*)

NO. 22

How is infringement determined?

ANSWER: The first step in determining infringement is to get a clear understanding of the mechanism or process which is suspicioned of being an infringement. Infringement actions usually arise through the complaint of salesmen of an organization about a competitor's activities and such complaints are habitually inaccurate. So the first step is to get at the facts to see just how the apparatus is made, how it operates and what it does.

The second step is then to submit this very complete showing preferably with photographs and drawings to a patent lawyer who will then compare the claims of your patent with the apparatus or process of the perspective defendant. To constitute infringement all of the elements of the claims must be used by the infringer. This does not mean that all of the elements of the construction must be called for by any one particular claim. The rules for interpretations of claims are numerous and difficult. The meaning of the claim must be determined in the light of the prosecution of the patent application in the Patent Office because a claim cannot be construed broadly enough to cover an infringer if, during the prosecution of the application, a claim to the same effect was voluntarily cancelled by the inventor or his attorney. Then too the lawyer must take into account the state of the prior patents because obviously a claim of a patent cannot be safely construed broad enough to cover an infringer if such a construction would cause a claim to read upon the prior art.

Nothing is more dangerous than to assume infringement simply because the claim on its face reads upon the defendant's construction of process. This is only the beginning of the investigation. The mere fact that the language seems to read on the defendant's construction may be just a fortuitous circumstance without there being any actual meaning.

After infringement is thus determined, the next step is to notify the defendant requesting him to cease his infringement. If he does not do so, then adequate steps can be taken in bringing a suit in the United States Court that has jurisdiction over the defendant. If the patent covers an apparatus or an article of manufacture the recovery will date either from the date of giving written notice or from the date when the number of the patent was placed upon the article made under the patent by the owner of it because the latter is a constructive notice to the infringer without the constructive figure of actual written notice.

It has been held by the courts that in the case of a process patent the requirement of a statutory notice does not apply because obviously you cannot mark an intangible thing.

In Wagner v. Corn Products Refining Co., 28 F. (2d), 617, it was stated:

". . . It is clear that section 4900, as well as its predecessors, imposing the duty to give notice, constructive or actual, is limited to tangible things, viz. 'patented articles'—things that can be marked or labeled. A process, as ordinarily understood, is not an article, and cannot be made to carry the prescribed notice. Its very character defies it being marked or labeled." (P. 618)

STAINLESS STEELS

Effects of Additions on Properties

STANLEY P. WATKINS

Manager, Development Division, Rustless Iron and Steel Corporation

IN ADDITION to chromium and nickel, which are the principal alloying elements in stainless steels, other elements are added to improve existing properties or impart special characteristics such as free-machining qualities. The several types of stainless steels produced by varying the number and proportions of the alloying elements, however, can be classified into three groups according to their analyses and heat-treating characteristics. Table I shows the analyses of the stainless steels in the three groups.

Group I—Straight chromium stainless steels hardenable by heat-treatment.

Group II—Straight chromium steels practically non-hardenable by heat-treatment.

Group III—Chromium nickel steels hardenable by cold work only.

In general, although the percentage added is small, each special alloying element is quite potent in producing new properties or modifying the original properties of the stainless steel. The more important effects produced by the various special alloying elements when added to the stainless steels are discussed in the following paragraphs.

CARBON—This element, since it is invariably present in all grades, is not ordinarily regarded as a special alloying element of the stainless steels, nevertheless, its effect on the properties of the stainless steels is of such importance as to deserve special consideration. The general effect of carbon is to increase the hardness and tensile strength of the stainless steels, and if present in considerable amounts, will adversely affect corrosion resistance, particularly, if the metal is not in the proper structural condition. Maximum corrosion resistance is obtained when carbon is in solution, which to effect, necessitates rapid cooling from above about 1,750 deg. F. for most grades. However, increasing chromium and nickel tends to minimize this effect. The effect of carbon content on the quench hardness of 12 percent and of 18 percent chromium stainless steels is shown by the curves in Figs. 1 and 2. When the chromium content is more than about 23 percent and the carbon under about 0.50 percent, the alloy cannot be hardened by heat-treatment.

In the straight chromium hardenable grades of stainless steel, carbon is very effective in regard to raising quench hardness and tensile strength. This is evidenced by typical tensile and hardness values of both high and low carbon grades in this group.

	Type 410	*Type 420*
	0.12 C	0.35 C
	12.00 Cr	12.00 Cr
Ult. strength lb. per sq.in.....	200,000	255,000
Brinell hardness...	401	535

	Type 430	*Type 440*
	0.10 C	1.00 C
	17.00 Cr	17.00 Cr
Ult. strength lb. per sq. in....	130,000	285,000
Brinell hardness...	240	627

In addition, raising the carbon content in the straight chromium hardenable grades lowers resistance unless they are in the full hardened condition. For example, in the case of the 0.10 percent carbon and 12 percent chromium grade of stainless steel, there is not a great deal of difference in corrosion resistance between the annealed and the full hard material. However, as the carbon content increases in this alloy to 0.35 percent, the resistance to

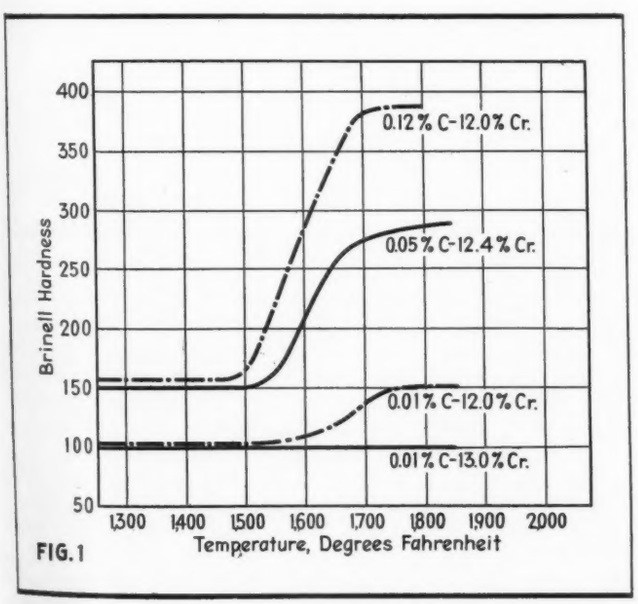


Fig. 1—Effect of carbon content on the quench hardness as exhibited by 12 percent chromium stainless steels

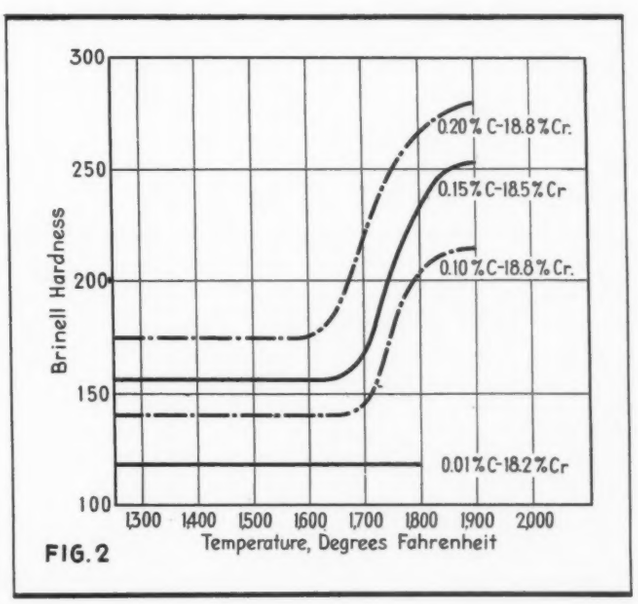


Fig. 2—Effect of carbon content on the quench hardness as exhibited by 18 percent chromium stainless steels

Table I–Effect of Alloy Additions on Stainless Steels

GROUP I—STRAIGHT CHROMIUM STAINLESS STEELS—HARDENABLE TYPES

Type No.	C	Mn	Si	S	Cr	Ni	W
403	0.15 max.	0.25/0.60	0.50 max.	0.03 max.	11.5/13.0	0.50 max.	.....
410	0.15 max.	0.25/0.60	0.50 max.	0.03 max.	10.0/14.0	0.50 max.	.....
414	0.15 max.	0.25/0.60	0.50 max.	0.03 max.	10.0/14.0	2.0 max.	.....
416	0.15 max.	0.25/0.60	0.50 max.	0.15 min.	12.0/14.0	0.50 max.	.....
418	0.15 max.	0.25/0.60	0.50 max.	0.03 max.	12.0/14.0	.....	2.5/3.0
420	0.40 max.	0.25/0.60	0.50 max.	0.03 max.	12.0/14.0	0.50 max.	.....
431	0.15 max.	0.25/0.60	0.50 max.	0.03 max.	14.0/18.0	2.0 max.	.....
440	0.60/1.10	0.25/0.60	0.50 max.	0.03 max.	14.0/18.0	0.50 max.	.....
441	0.15 min.	0.25/0.60	0.50 max.	0.03 max.	14.0/18.0	2.0 max.	.....

GROUP II—STRAIGHT CHROMIUM STAINLESS STEELS—NON-HARDENABLE TYPES

Type No.	C	Mn	Si	S	Cr	Ni
430	0.12 max.	0.25/0.60	0.50 max.	0.03 max.	14.0/18.0	0.50 max.
430-F	0.12 max.	0.25/0.60	0.50 max.	0.15 min.	14.0/18.0	0.50 max.
442	0.35 max.	0.25/0.80	1.0 max.	0.03 max.	18.0/23.0	0.50 max.
446	0.35 max.	0.25/0.80	1.0 max.	0.03 max.	23.0/30.0	0.50 max.

GROUP III—CHROMIUM-NICKEL STAINLESS STEELS—HARDENABLE BY COLD WORK ONLY

Type No.	C	Mn	S	Cr	Ni	Mo	Cb	Ti	Se
302	0.80/0.20	1.25 max.	0.03 max.	17.5/20.0	8.0/10.0	.....	.....	.....	.....
303-S	0.20 max.	1.25 max.	0.15 min.	17.5/20.0	8.0/10.0	.....	.....	.....	.....
303-Se	0.20 max.	1.25 max.	0.03 max.	17.5/20.0	8.0/10.0	.....	.....	.....	0.15 min.
304	0.08 max.	2.0 max.	0.03 max.	18.0/20.0	8.0/10.0	.....	.....	.....	.....
308	0.08 max.	2.0 max.	0.03 max.	19.0/22.0	10.0/12.0	.....	.....	.....	.....
309	0.20 max.	2.0 max.	0.03 max.	22.0/26.0	12.0/14.0	.....	.....	.....	.....
310	0.25 max.	2.0 max.	0.03 max.	24.0/26.0	19.0/21.0	.....	.....	.....	.....
312	0.25 max.	2.0 max.	0.03 max.	27.0/31.0	8.0/10.0	.....	.....	.....	.....
316	0.10 max.	2.0 max.	0.03 max.	16.0/18.0	10.0/14.0	2.0/3.0	.....	.....	.....
317	0.10 max.	2.0 max.	0.03 max.	18.0/20.0	10.0/14.0	3.0/4.0	.....	.....	.....
321	0.10 max.	2.0 max.	0.03 max.	17.0/20.0	7.0/10.0	.....	.....	4×C	.....
347	0.10 max.	2.0 max.	0.03 max.	17.0/20.0	8.0/12.0	.....	10×C	.....	.....

attack by corrosion is materially lowered if material is in the annealed condition. It is necessary, therefore, that this type of alloy be in the full hard condition in order to develop maximum corrosion resistance. Tempering up to 750 deg. F. to relieve hardening strains will not affect corrosion resistance.

Increasing carbon content of the straight chromium stainless steels tends to lower machinability, especially when in excess of about 0.30 percent. With carbon greater than this value, hard cementite particles are present which are abrasive to cutting tools.

In the chromium-nickel grades of stainless steel, a high carbon content is usually considered detrimental in materials that are to be welded, or in materials that are to be subjected in service to temperatures ranging between 750 and 1,600 deg. F. This is because the solubility of carbon in the chromium-nickel stainless steels is quite low—approximately 0.02 percent. Carbon in excess of this amount is precipitated out along the grain boundaries when alloys of this type are heated within the above range for extended periods. Also, the heat generated by welding is sufficient to precipitate carbides to a harmful degree. Since material containing excessive carbide precipitation is subject to intergranular attack when exposed to severe corrosive conditions, the carbon content is maintained as low as is consistent with economical manufacturing operations. Experience has shown that if the carbon content is maintained below 0.08 percent in the chromium-nickel stainless steels, that such materials are satisfactory for welding operations and also many high temperature applications.

If the carbon is in solution, effected

by quenching from above about 1,850 deg. F. in the case of the 18–8 alloys, it is not detrimental from a corrosion standpoint, providing of course, the material is not subjected to the range of 750–1,600 deg. F. in service. Consequently, it is not so important that such material be held to a low carbon content.

On the other hand, test data show that carbon is helpful in improving the tensile strength of the 18–8 alloys in the annealed conditions.

	Type 302	*Type 304*
	0.15 C	0.05 C
	18.00 Cr	18.00 Cr
	8.00 Ni	8.00 Ni
Ult. tensile strength lb. per sq.in.....	100,000	90,000
Yield point lb. per sq.in.....	38,000	33,750
Elongation percent.....	62.0	60.5
Brinell hardness....	146	159

The influence of carbon on the cold working characteristics of 18–8 stainless steel wire is shown by Fig. 3. The effect of increasing carbon is to increase work hardening rate.

MANGANESE—As a general rule the commercial straight chromium stainless steels do not contain large amounts of manganese, frequently there is not more than 0.30–0.60 percent in these alloys. Rarely does the manganese exceed 1.50 percent. Increasing the manganese above about 3 percent in the 12–14 percent chromium stainless steels serves to increase tensile strength and hardness but decreases elongation. In addition, the corrosion resistance of such alloys is reduced if more than 4 percent manganese is present.

Low carbon, 18 percent chromium stainless steels containing about 6 percent manganese, are relatively soft, ductile and tough. Increasing the manganese content to 8–10 percent improves these properties further, and if it is raised to about 14 percent, ductility is improved slightly. Low carbon alloys containing 18 percent chromium and 8–10 percent manganese are not wholly austenitic, even when rapidly cooled from 1,850–1,950 deg. F. However, with manganese in the neighborhood of 14 percent and the carbon content fairly high, a fully austenitic structure is obtained by quenching from about 1,900 deg. F. Like the austenitic 18–8 stainless steels, these alloys are softened by rapid cooling from temperatures in the 1,850–2,100 deg. F. range.

In the annealed condition, the 18 percent chromium-10 percent manganese stainless steels possess good resistance to atmospheric conditions, and while they resist attack by a large number of industrial chemicals, they are not so resistant to so great a variety of corroding media as the 18 percent chromium-8 percent nickel stainless steels. However, they offer adequate resistance to fruit and food juices, and weak solutions of such acids as nitric, carbolic and lactic. Similarity to the austentic chromium-nickel stainless steels, the 18 percent chromium-10 percent manganese alloys when exposed to sensitizing range 750–1,600 deg. F., are subject to intergranular corrosion.

Although manganese in the straight chromium stainless steels, and in the lower chromium-nickel analyses such as 18 percent chromium-8 percent nickel, is maintained generally below 1.0 percent, experience has shown that in the higher chromium-nickel steels such as 25 percent chromium-12 percent nickel and 18 percent chromium-8 percent nickel-3 percent molybdenum, maintaining the manganese above 1.50 percent in these grades materially improves hot working properties.

The addition of manganese to the straight chromium stainless steels improves welding properties and in the case of alloys containing about 18 percent chromium-10 percent manganese, welding characteristics are similar to the austenitic chromium-nickel stainless steels.

SILICON—In almost every way the effect of silicon on the structural properties of the straight chromium stainless steels is the reverse of that produced by nickel. Silicon in amounts greater than about 1 percent in the hardenable types of these alloys reduces air hardening capacity and raises the temperature to which the steels must be heated to effect full hardening. In addi-

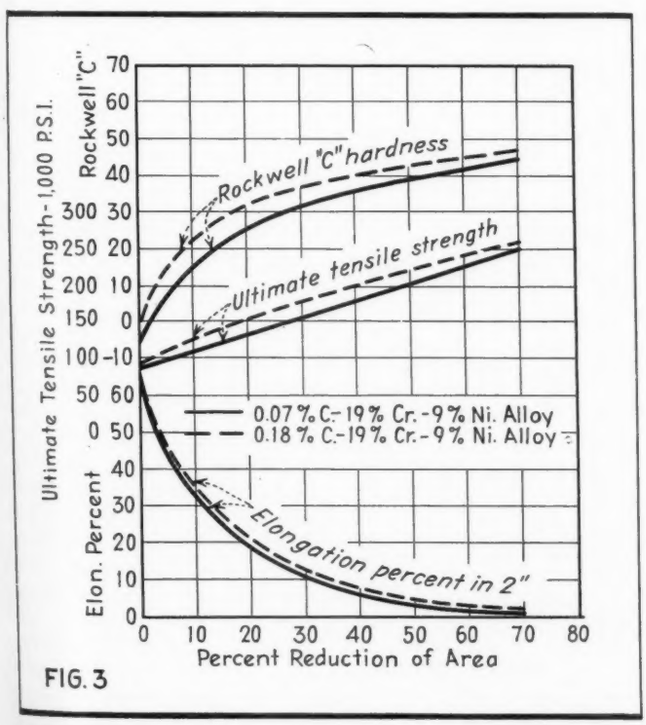


Fig. 3—Influence of carbon content on the cold work hardening characteristic of 18-8 stainless steel wire

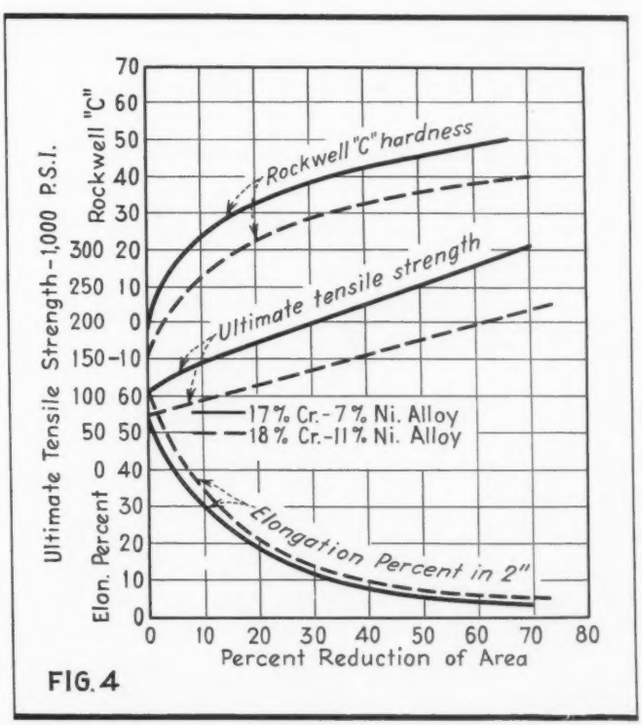


Fig. 4—Difference in work hardening characteristics between low and high alloy 18–8 stainless steel wire

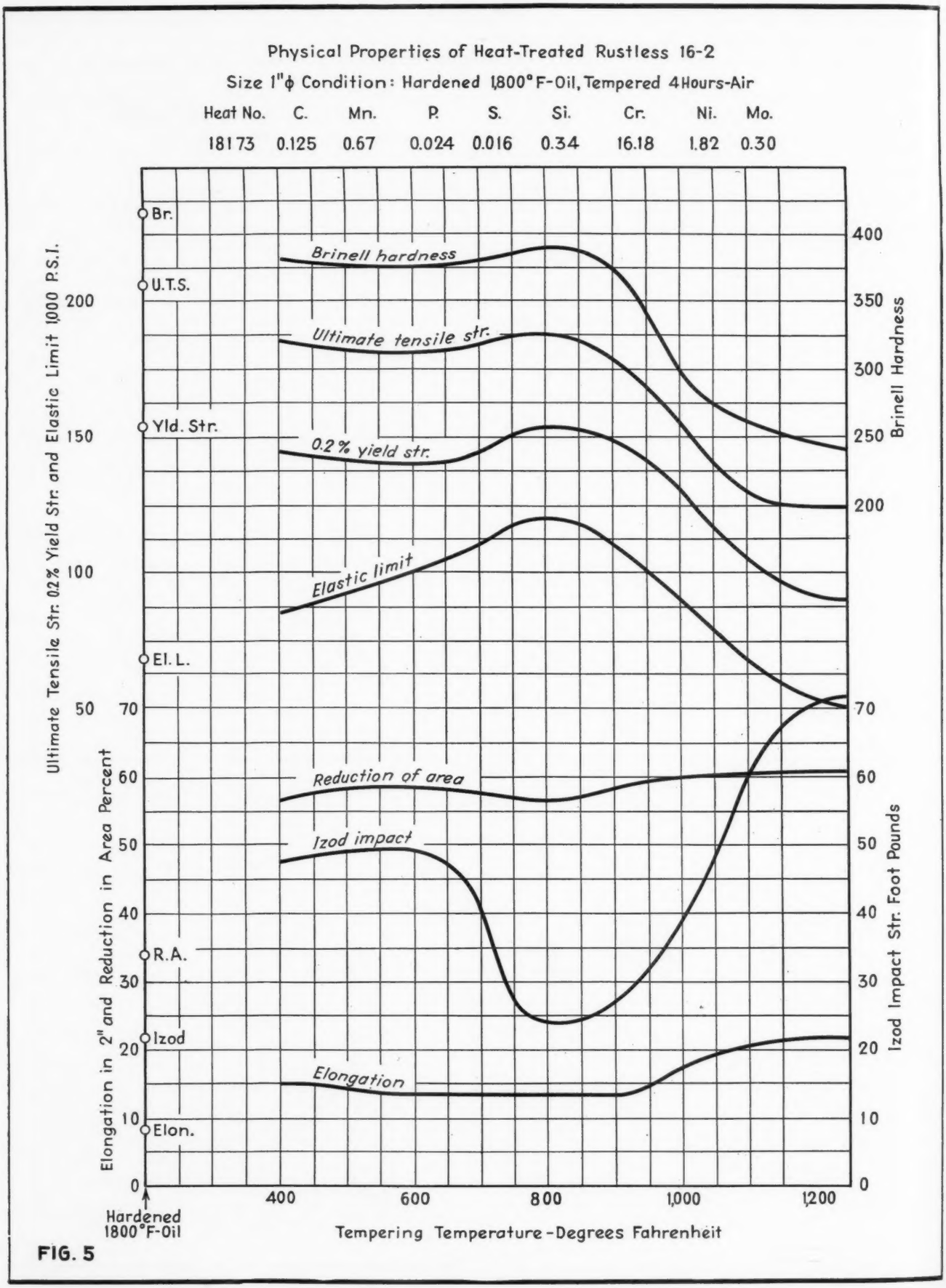


FIG. 5

Fig. 5—Properties obtainable in a 16 percent chromium and 2 percent nickel stainless steel with various tempering procedures

tion, when silicon content exceeds about 1 percent the impact strength of these alloys is materially reduced.

The general corrosion resistance of the straight chromium stainless steels is not materially improved by the addition of silicon. However, it has been observed that silicon in the amount of about 1.25 percent improves the resistance of a 13 percent chromium stainless steel to attack by sulphuric acid solutions. The chief advantage accruing from the addition of silicon to the straight chromium stainless steels is to increase resistance markedly to oxidation at high temperatures. An alloy having about 3 percent silicon will show very little, if any, oxidation when exposed to temperatures around 1,650 deg. F., whereas, a similar alloy with silicon under 0.50 percent will be heavily oxidized when exposed to such temperatures.

Silicon improves the oxidation resistance of the austenitic chromium-nickel stainless steels, and is most effective in this respect when present in amounts above about 2 percent. This amount of silicon does not materially affect tensile properties, although there is some evidence that impact strength is lowered.

The resistance of the austenitic chromium-nickel stainless steels to cold dilute hydrochloric acid and hot dilute sulphuric acid is improved by the addition of about 3 percent silicon. However, resistance to nitric acid is decreased by silicon. It has been observed that a high silicon content in the 18–8 stainless steel improves resistance to intergranular corrosion, and such material has been used for applications involving welding.

NICKEL—Although nickel in the straight chromium steels is usually less than 1 percent, a group of alloys containing from 12 to 18 percent chromium and 1 to 3 percent nickel have received considerable attention, primarily for aircraft construction. An alloy containing about 0.12 percent carbon, 16 percent chromium and 2 percent nickel is a heat-treatable alloy which, as shown by Fig. 5, can be hardened and tempered to obtain a wide range of tensile properties.

Raising nickel content in the straight chromium stainless steels serves to increase hardenability, tensile strength and impact strength. Also, the addition of above about 1 percent nickel to these alloys renders them air hardening, and such material should be slowly cooled from the rolling or forging heat. Nickel serves to increase the corrosion resistance of the straight chromium stainless steels, particularly to salt spray and atmospheric conditions. The toughness of these alloys is increased by nickel, hence, machining is more difficult.

Increasing nickel in the 18–8 stainless steels above the normal range increases corrosion resistance, and tends to reduce cold working capacity. As the nickel is increased, as shown by Fig. 4, the susceptibility to harden by cold deformation is reduced. Low work hardening 18–8 is highly desirable for applications involving cold upsetting, but not so suitable for making high tensile material by cold rolling or drawing.

MOLYBDENUM—The addition of this element to the straight chromium stainless steels serves to increase general corrosion resistance, and especially improves resistance to attack by weak solutions of the common acids. Amounts as low as 0.50 percent will effect definite improvement in corrosion resistance, but full effect is obtained with about 2 percent. The hardenability of these alloys is reduced by molybdenum, and machinability improved.

Molybdenum in the austenitic chromium-nickel stainless steels increases resistance to attack by the common acids, and reduces tendency to pit when exposed to chloride solutions. To be effective, the molybdenum should be above about 2 percent in these alloys. The addition of molybdenum does not materially alter tensile properties at normal temperatures, but does serve to improve creep and tensile strength at elevated temperatures.

Since molybdenum promotes formation of the ferritic phase in the austenitic chromium-nickel stainless steels, alloys containing above about 2 percent do not work harden as rapidly as those free of this element. Also, the presence of free ferrite causes these alloys to be slightly magnetic.

TITANIUM—A useful property of titanium is to reduce the hardening capacity of the straight chromium stainless steels, and thus render them more suitable for welding operations. In order to produce this effect, titanium should be present in a ratio of 5 to 7 times the percentage of carbon. Titanium does not improve the corrosion resistance of the straight chromium stainless steels; however, it slightly increases both oxidation resistance and creep strength.

When added to the austenitic chromium-nickel stainless steels, titanium is said to "stabilize" the carbon and thus to reduce susceptibility to intergranular corrosion. Titanium is present in the commercial grades to the extent of five times the carbon content and in addition the alloy is generally given a "stabilizing" treatment consisting of heating in the range of 1,550–1,650 deg. F. for about 3 hr. Titanium improves the resistance of 18–8 stainless steels to attack by boiling nitric acid when heated in the "sensitizing" range as shown by Fig. 6. The general corrosion resistance of these alloys is not improved by the addition of titanium, but toughness and corrosion resistance at elevated temperatures is increased.

Although titanium bearing 18–8 stainless steel is highly satisfactory for welding, the alloy in the form of weld-

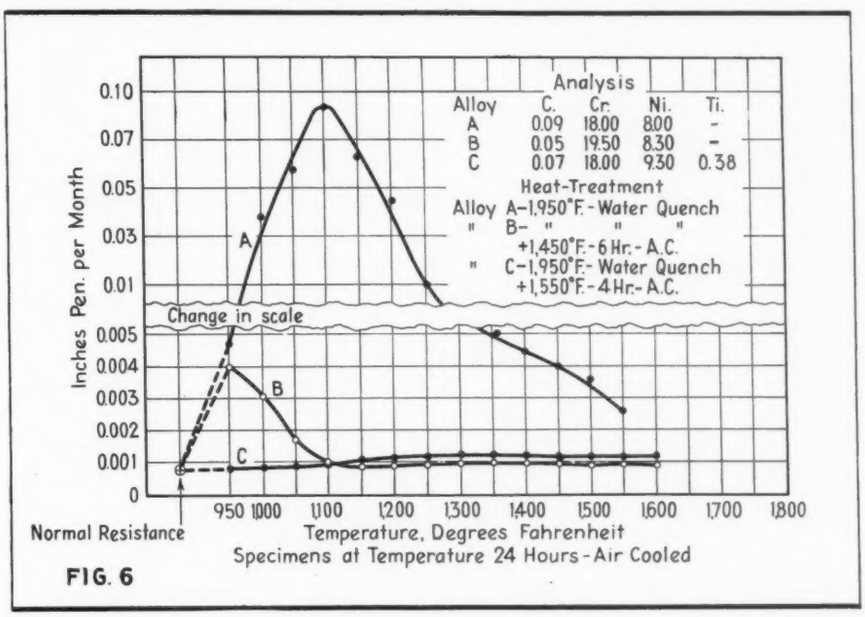


Fig. 6—Effect of 65 percent boiling nitric acid test on sensitized 18–8 alloys. Note how low carbon and titanium improve resistance

ing rod is unsuitable, as in welding the titanium is oxidized and the resulting weld metal is not immune to intergranular attack. Plates and sheets of this material should be welded with columbium bearing weld rod.

COLUMBIUM—When this element is present in the straight chromium stainless steels in amounts 8 to 10 times the carbon content, hardenability is considerably reduced and the tendency to air harden is largely overcome. The corrosion and oxidation resistance of these alloys is improved somewhat by the addition of columbium. On the other hand, tensile strength at normal temperatures is reduced.

A large tonnage of 18–8 stainless steels containing columbium in the amount of about 10 times carbon content is used for fabricating equipment by welding, which is subsequently exposed to severe corrosive conditions or subjected to temperatures in the range of 750–1,550 deg. F. The effect of columbium in these alloys is said to be similar to that of titanium, in that it "stabilizes" carbon and thus minimizes the tendency for intergranular corrosion to occur. However, unlike titanium bearing 18–8, it is not necessary to give columbium bearing 18–8 a "stabilizing" heat-treatment if the columbium-carbon ratio is above 10 to 1. Also in welding, columbium is not oxidized to the same extent as is titanium, thus making it a highly satisfactory addition to 18–8 welding rods.

The general corrosion resistance of the austenitic chromium-nickel stainless steels is not improved by the addition of columbium. Tensile properties at normal temperatures are somewhat improved, provided the columbium is maintained in the proper ratio. Toughness at elevated temperatures is improved by columbium.

SULPHUR AND SELENIUM—These elements when present in amounts between 0.15 and 0.35 percent impart free-machining and non-galling characteristics to stainless steels. Molybdenum to the amount of 0.40 percent is generally added in combination with sulphur and approximately 0.15 percent phosphorus with selenium. The selenium-phosphorus combination is not generally added to the straight chromium stainless steels, as sulphur and molybdenum impart better machining properties in these grades. Both combinations are added to the 18–8 stainless steels, but the sulphur-molybdenum combination is more effective as regards imparting free-cutting qualities, whereas, the selenium-phosphorus grade while not so easily cut yields a more lustrous finish after machining.

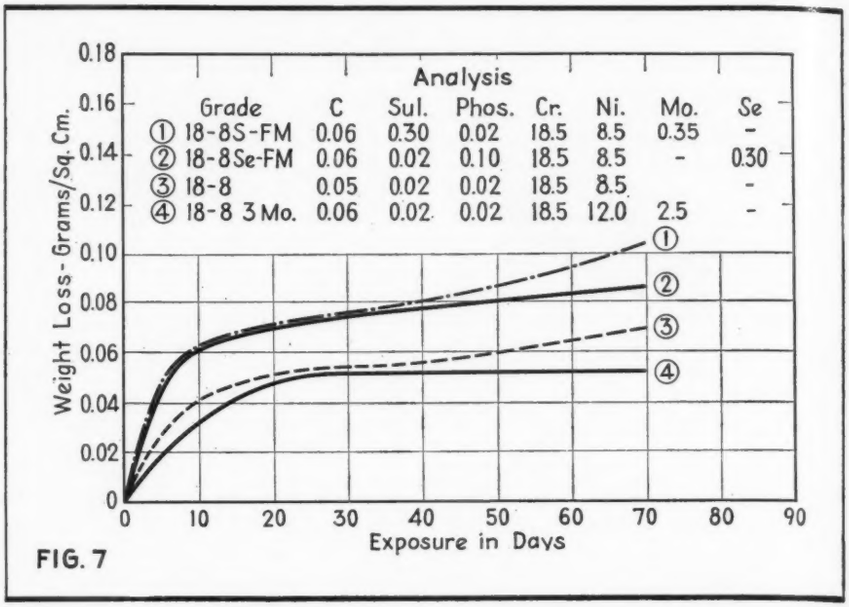


Fig. 7—Comparative resistance of the 18–8 free-machining grades and two regular grades to a dilute mixed nitric and sulphuric acid solution at room temperature

Sulphur and selenium slightly reduce elongation and impact strength to the stainless steels, but otherwise tensile properties are not changed materially. The free-machining stainless steels are somewhat more difficult to hot work than the regular grades, and also oxidation resistance is slightly reduced. General corrosion resistance, such as exposure to the atmosphere, fruit and food juices, is not materially affected, but these elements do reduce resistance to hot acid solutions. Fig. 7 shows the comparative resistance of the 18–8 free-machining grades and two regular grades to a dilute solution of nitric-sulphuric acid.

OTHER ELEMENTS—In addition to the elements discussed which are the more important ones, other elements such as aluminum, copper, nitrogen and tungsten are added to the stainless steels to obtain various special properties. These alloys are not used to any great extent, hence they are not produced in large tonnages, such as are, for instance, the grade containing columbium.

In the straight chromium stainless steels aluminum reduces hardenability, and when present to the amount of about 1 percent, the medium carbon 12 percent chromium alloys do not harden appreciably even when quenched from above 1,850 deg. F. Impact strength is reduced by aluminum, but oxidation resistance is improved considerably. Also, electrical resistance is increased and at elevated temperatures aluminum increases resistance to attack by oxygen and other gases.

The effect of copper additions on the properties of the stainless steels have been studied extensively in this country, but such alloys have not been produced in quantity. In the case of straight chromium stainless steels, copper slightly increases resistance to attack by sulphuric and hydrochloric acids, and when present in appreciable amounts improves machinability. Copper in the chromium-nickel stainless steels produces much the same effect as when added to the straight chromium grades. With copper above about 3 percent the chromium-nickel grades are difficult to hot work.

Nitrogen in the medium carbon straight chromium stainless steels serves to increase hardenability and in this respect acts much the same as carbon. This effect is not accompanied by embrittlement or by reduced resistance to corrosion. In the high chromium alloys, 18 to 30 percent, nitrogen serves to retard grain growth at elevated temperatures.

The hardenability of the straight chromium stainless steels is not affected by the addition of tungsten, but strength at elevated temperatures is increased. Corrosion resistance is not improved, in fact, resistance to nitric acid is decreased.

Tungsten in the 18–8 stainless steels improves strength and resistance to creep at elevated temperatures. Amounts above about 4 percent make these alloys difficult to hot work. This element also serves to improve oxidation resistance and to increase hot hardness; properties which are both highly desirable for combustion exhaust valves.

JOGGING CIRCUITS

For Inching Machines With Motor Drives

J. H. LEWIS
Industrial Control Engineer, General Electric Company

ELECTRIFICATION of drives for machines is now employed to such an extent that a working knowledge of electrical circuits by engineering designers is a necessity. Basic principles are, in general, well understood. Some misunderstanding still exists, however, as to what is meant by "jogging" and as to how this operation can be best accomplished. "Jogging," or "inching" as it is sometimes called, is a minor but basic requirement of control that is frequently necessary for the successful performance of many machines. The National Electrical Manufacturers' Association has prescribed that:

> "'Jogging' or 'inching' is the quickly repeated closure of the circuit to start a motor from rest for the purpose of accomplishing small movements of the driven machine."

A study of this definition indicates that it is immaterial whether the controlling means for the drive allows the motor to continue operating at a slow or reduced speed, or whether it allows the motor to accelerate to its base speed. Confusion exists at this point because some designers believe a slow speed, during which the motor does not accelerate, constitutes jogging. Others believe that even though the motor accelerates, jogging is still obtained. It is true that jogging action may be obtained from a control which permits either of these types of motion by the motor through the proper operation of the jog button. This is evident from the N.E.M.A. definition, since the objective of the jogging action is to secure small movements of the driven machine by starting the motor from rest for each "jog."

In terms of performance a circuit which allows the motor to run at slow speed gives a "creep" or "thread" operation. A good example of an application of this type of circuit is in the cloth printing machine, shown in Fig. 1, which is driven by an adjustable speed d.c. motor. A maintained slow speed is essential when threading the cloth through the rolls and when inspecting the pattern "fit." Control for this type of operation is usually special as some means for applying and maintaining reduced voltage to the motor is required. The panel consequently will be larger and more expensive than that required for straight jogging control. For the purposes of this discussion, jogging only as defined by the N.E.M.A. will be considered hereafter.

Jogging is required in order to bring a tool up to the work, or the work up to the tool, in fine increments for line-up or adjustment. It is, therefore, vitally necessary that the control performing this operation be reliable. When the jog button is pressed the operation must start, and when the button is released the operation must stop. Safety to the operator and to the machine demand this. It is easy to understand how the work or the tool may be damaged by failure to stop. Likewise it is possible to visualize what might happen to a boring mill operator when working inside a casting for set-up, should he jog the table up to the tool and the table

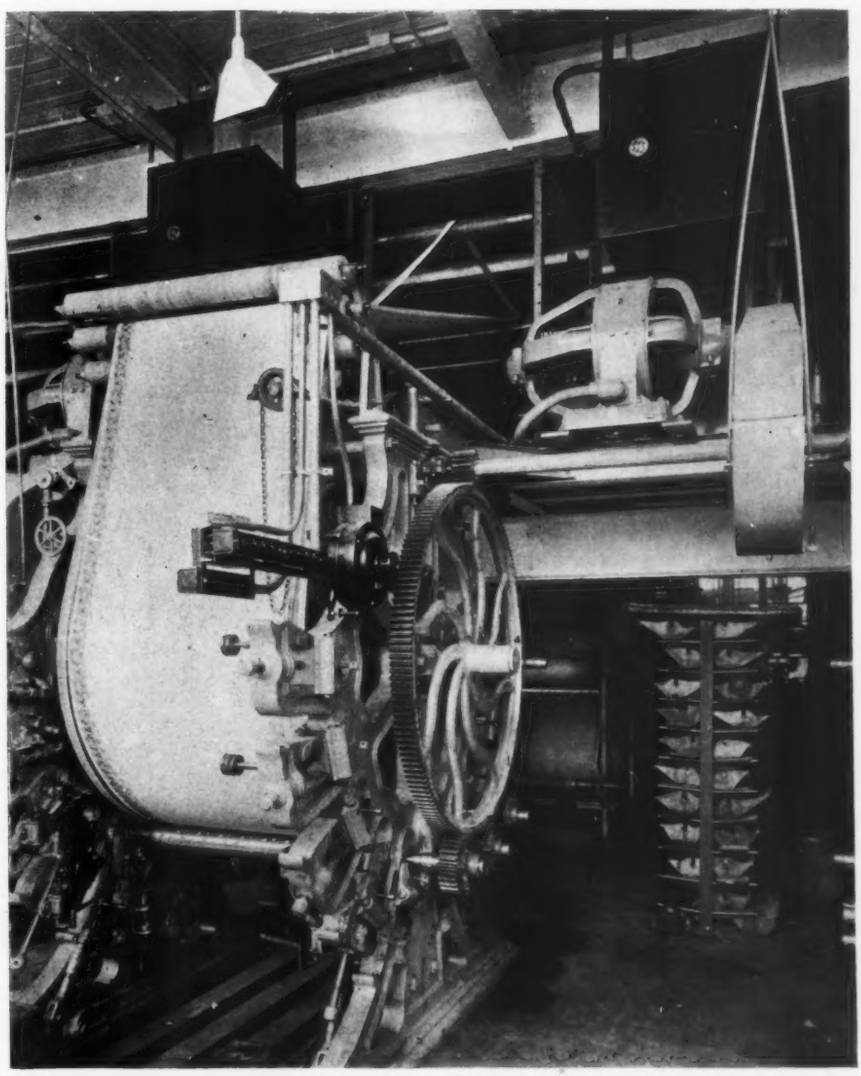


Fig. 1—Pushbutton stations and control panel on a range-drive cloth-printing machine driven by an adjustable speed d.c. motor

	Pushbutton, normally closed		Shunt coil
	Pushbutton, normally closed and normally open		Selector switch, normally closed and normally open
	Pushbutton, normally open	LE	Line contactor operating coil
	Interlock, normally open	CR	Control relay operating coil
	Interlock, normally closed	OL	Overload relay control contact

Fig. 2—Symbols and legends used in accompanying schematic diagrams to denote circuit elements

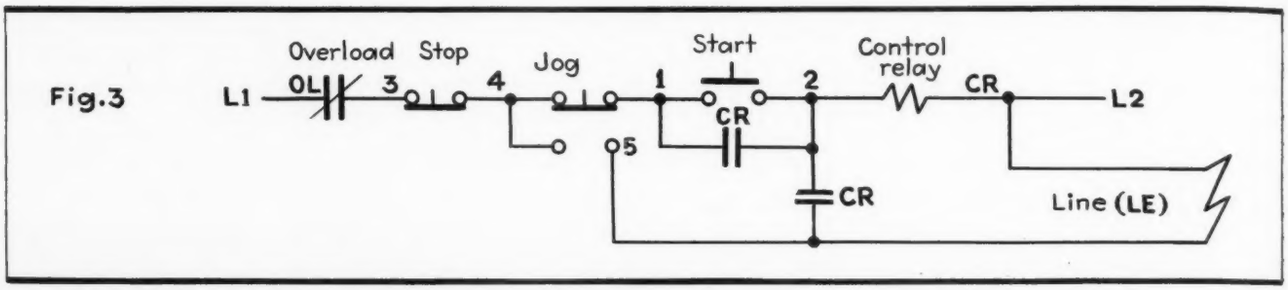


Fig. 3—Jogging circuit in which is included a separate control relay and in which the line contactor is not "held in" so that when set for jogging all possibility of the machine continuing to run is eliminated

fail to stop. On the other hand, of course, not every machine which must be jogged involves a hazard to the operator or to the machine. But if injury or damage can result from continued running of the machine when the operator intended to jog only, then some safe method of jogging must be used. To insure safety, the "sealing" or "holding" circuit for the contactor applying power to the motor must be positively opened when the jog button is released by the operator.

Several simple and reliable methods of jogging will be described and illustrated with schematic circuit diagrams. The symbols used in the circuit diagrams are shown in Fig. 2 with explanatory legends.

The safest method of jogging uses a separate control relay as shown in Fig. 3. Wired up in this manner, there is no "hold-in" circuit for the line contactor. The line contactor *LE* picks up when the jog button is pressed and drops out when the button is released. The control relay *CR* is not energized for this operation; so there is no possibility of accidentally maintaining a holding circuit to *LE*. A normal start operation energizes the *CR* relay which in turn energizes *LE*. This circuit is also used when operation from small pendant push buttons is required, because of the small tip gap present in these stations and the inherent difficulty of making a satisfactory latch, and in addition the possibility of the arc maintaining itself across the small gap.

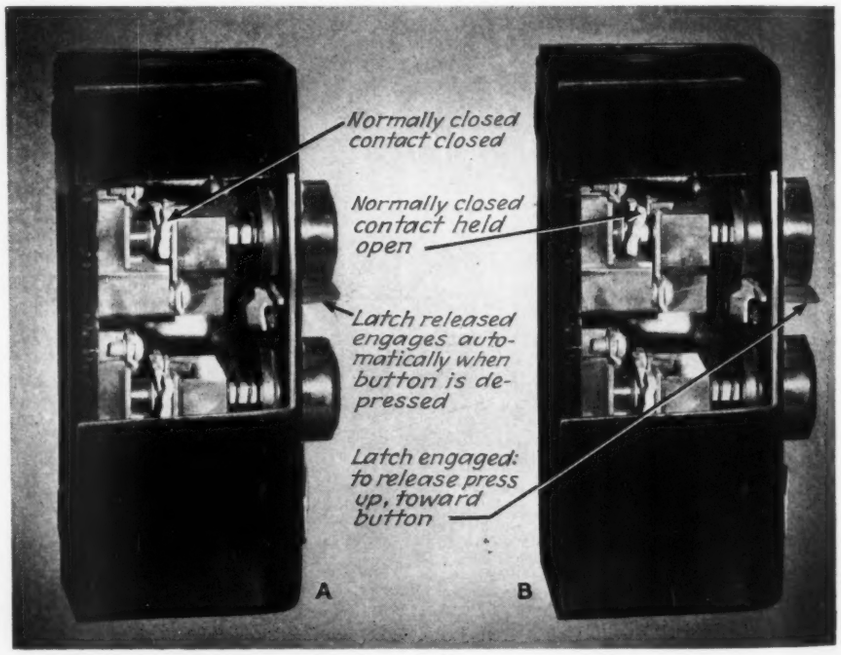

Normally closed contact closed
Normally closed contact held open
Latch released engages automatically when button is depressed
Latch engaged: to release press up, toward button
A
B

Fig. 4—(A) Jogging button station with safety latch in normal position. (B) in position for jogging the machine

In order to hold open mechanically the normally closed contacts when the button is pressed, jog buttons are available with latches. This construction can be seen in Fig. 4(*A*) and (*B*). In Fig. 4(*A*) the jog button is in the normal position with the normally-closed contacts closed and the latch released. In Fig. 4(*B*) the jog button has been pressed and the latch has engaged, as a result the normally-closed contacts are mechanically prevented from closing. The latch is spring biased, that is spring opposed so that even though the button

may continue to be operated, the latch will engage each time the button is released.

A frequently used control shown in Fig. 5, in which a jog button with a latch is used, provides an effective and reliable circuit. When the jog button is pressed the *LE* contactor picks up, and its "hold-in" interlock *LE* 1–2 closes. A holding circuit is not maintained, however, as the jog button circuit 4–1 is open and mechanically held open until the latch is released. After the latch is released manually, circuit 4–1 closes and normal start may be obtained. Inasmuch as this circuit has one less relay and fewer wires between the pushbutton and panel, the control will be less expensive than that shown in Fig. 3. In addition the control panel will be smaller. This is sometimes an advantage especially when the control is built into a machine.

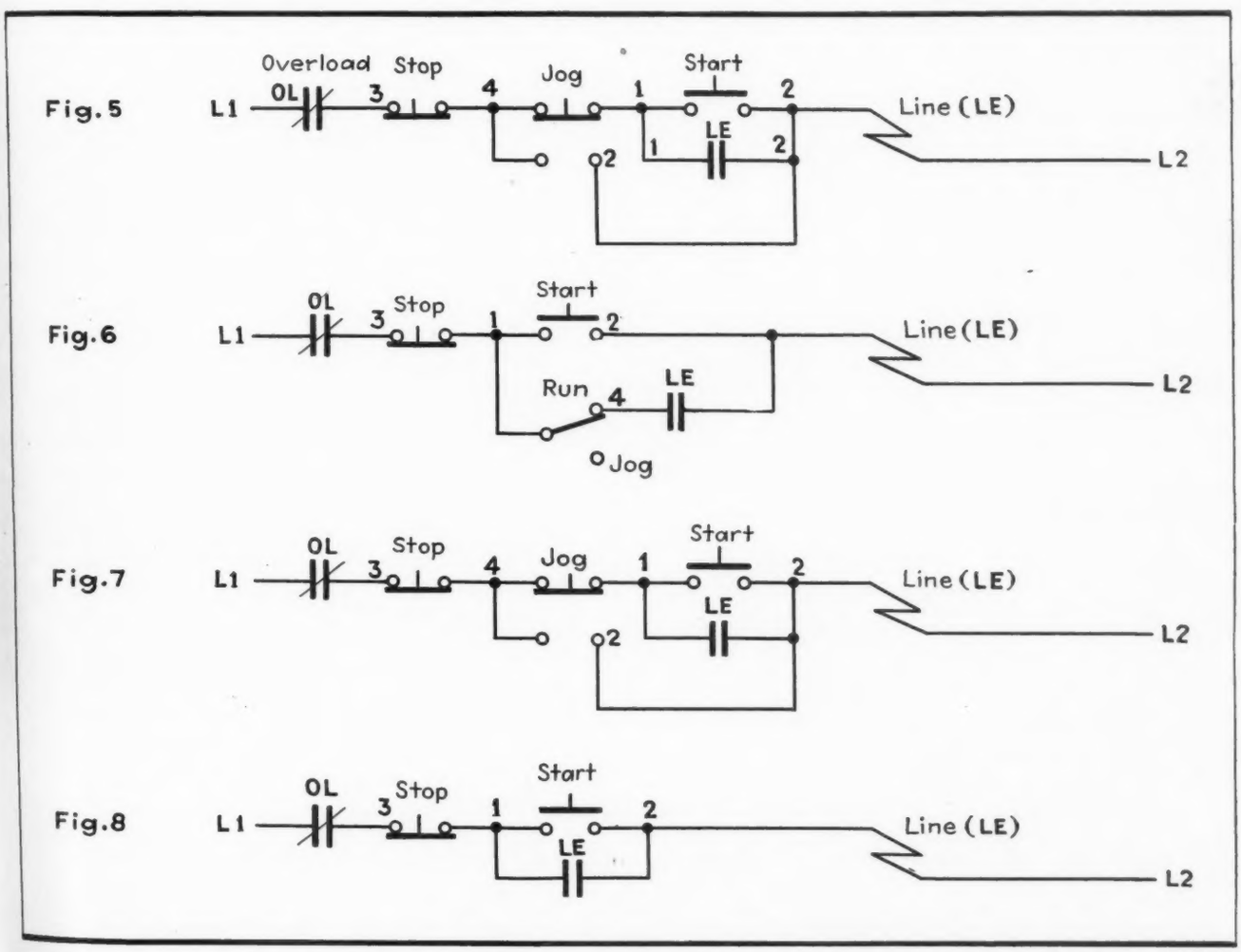
The arrangement shown in Fig. 6 will provide reliable jogging action if the operator selects the proper position on his two position selector switch. In this circuit a "run-jog" maintaining contact selector switch is in series with *LE* "hold-in" circuit 4–2. With the selector set on the jog position, the "start" button may be operated for jogging and no chance exists for the "hold-in" circuit to be maintained. Normal operation is secured by setting the switch on "run" and operating the "start" button. The "start" button has a dual function in this circuit as both a "start" and a "jog" button. This is not considered good practice as it may lead to incorrect operation. The recommended procedure is to have a push button for each functional operation of the machine.

Another circuit shown in Fig. 7 will provide jogging. But experience has shown that an operator, who is intently watching the results of the jogging action of his machine, will operate the jog button rapidly. As a result, it is possible for the back contacts 4–1 of the jog button to close before the "hold-in" interlock *LE* 1–2 has opened. Should this occur, the machine will continue to run and injury to the operator or damage to the machine may result.

An expedient to secure infrequent jogging can be obtained with a "start-stop" pushbutton connected as shown in Fig. 8. Alternately operating the "start-stop" button gives jogging action to the machine. Another method, using the same circuit, consists of holding both buttons depressed and working the "stop" button in and out. The "start" button must be released before the "stop" button after the jogging cycle is completed. It must be remembered that this is an expedient and not a recommended control circuit.

These control circuits are basic and applicable to more involved circuits, either a.c. or d.c., which provide reduced voltages, specific torques, or other special requirements from the driving motor. The designer should select the method he will use to control the machine when he first considers his circuit requirements.

The circuits shown in Figs. 3 and 5 are most frequently used, and are in constant and successful use on a large number of different types of machines. For maximum safety, the method shown in Fig. 3 is recommended.



Figs. 5, 6, 7, 8—Typical jogging circuits used to obtain small movements of motor driven machines

DESIGNS FOR APPLYING

R. J. HINKLE
The Garlock Packing Company

BEARING seal units made in sizes to press-fit in S.A.E. or International millimeter bores as standardized by ball and roller bearing manufacturers are available as purchased units. The seal element is its own cap and thus contributes to low-cost design, construction and assembly, and reduces the number of parts. Various applications show versatility of design with this type seal.

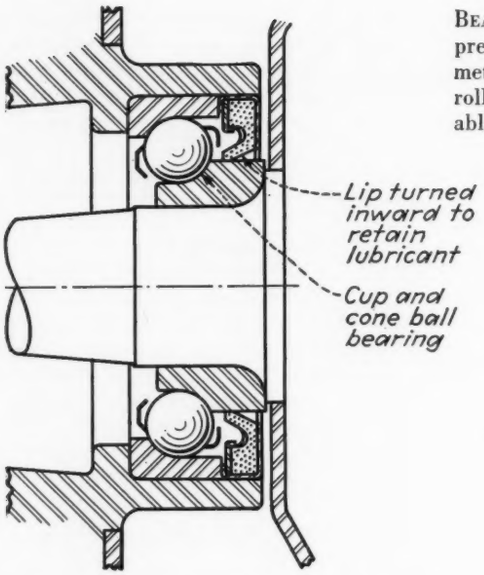


Fig.1-Automobile Front Wheel Bearing

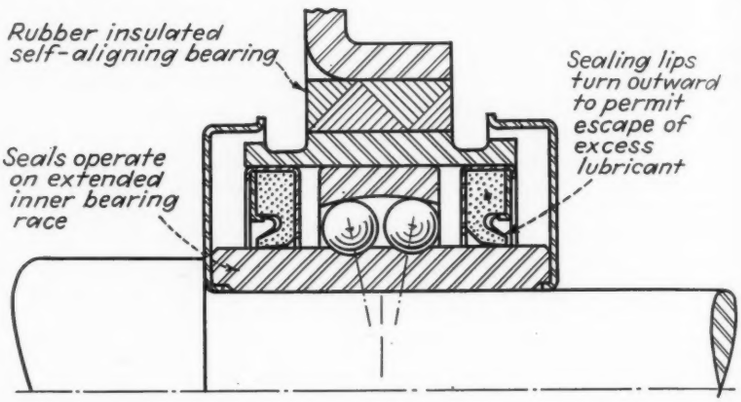

Rubber insulated self-aligning bearing
Sealing lips turn outward to permit escape of excess lubricant
Seals operate on extended inner bearing race

Fig.2-Propeller Shaft Bearing for Truck or Bus

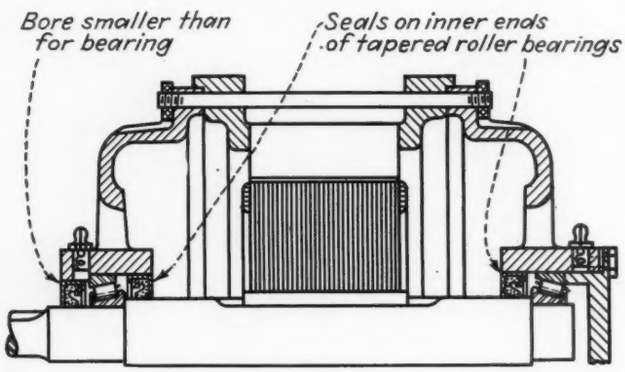
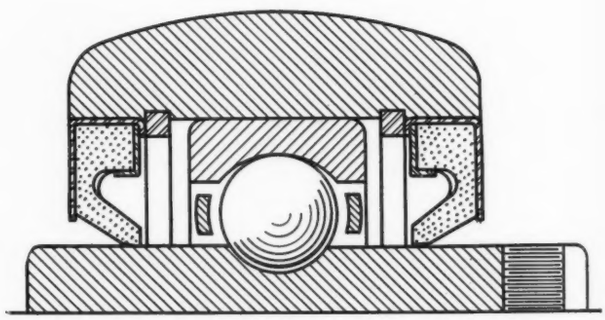
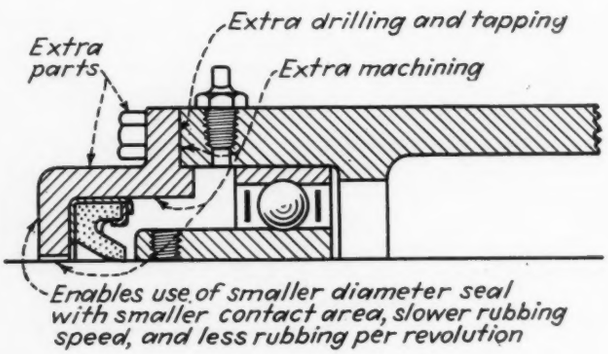


Fig.3-Small Electric Motor

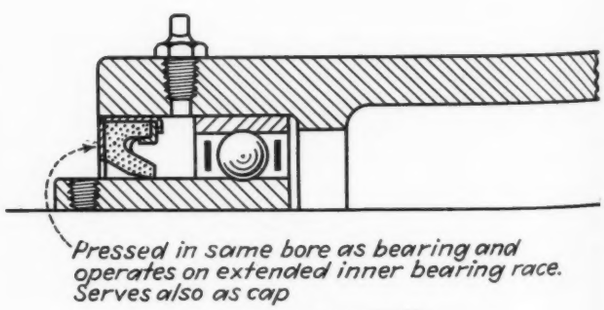


Deep groove type bearing with rigid pillow block

Fig.4-Self-Aligning Bearing


Extra drilling and tapping
Extra parts
Extra machining
Enables use of smaller diameter seal with smaller contact area, slower rubbing speed, and less rubbing per revolution

Conventional Plate Mounting



Unit Seal Mounting

Fig.5-Fan or Blower Housings

PRESS-FIT SEAL UNITS

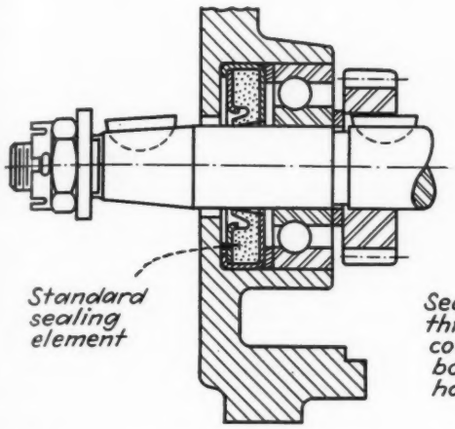


Fig.6- Magneto Drive Shaft

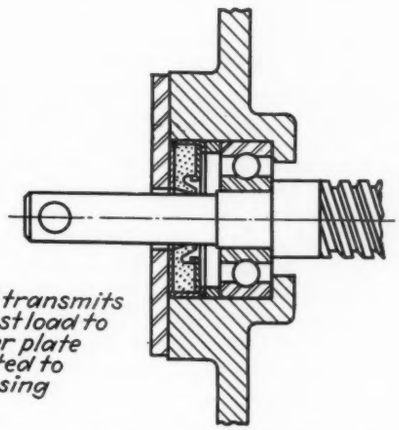


Fig.7- Small Worm Shaft

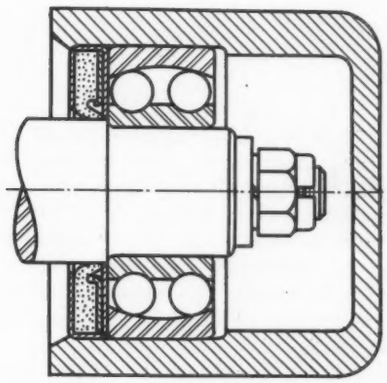


Fig.8-Compressor Shaft Bearing and Closure

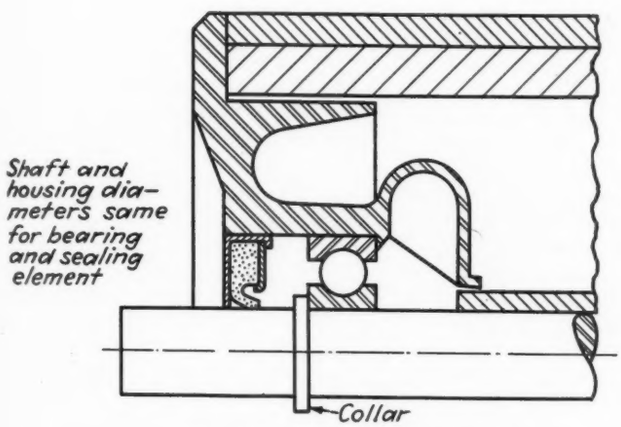


Fig.9- Idler Shaft

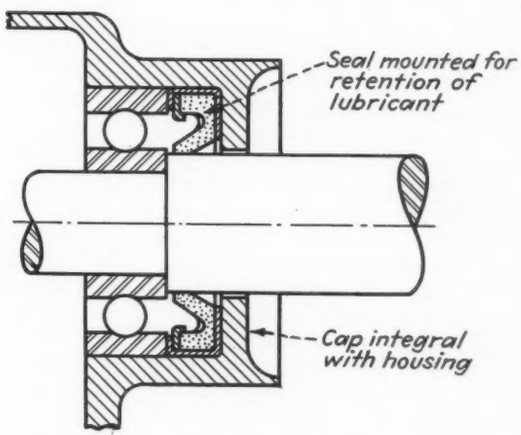


Fig.10- Reel Shaft of Tractor-Drawn Mower

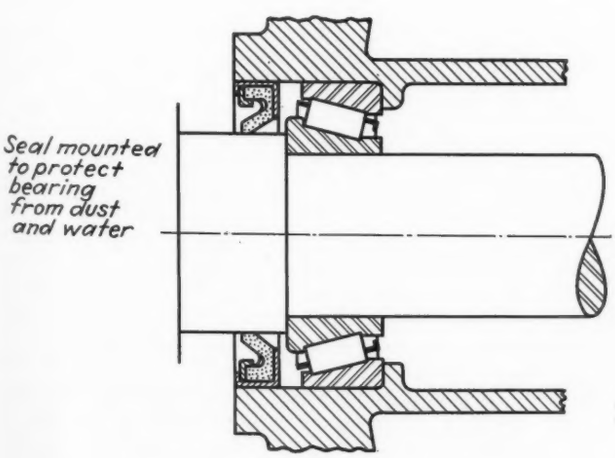


Fig.11- Agricultural Vehicle Wheel

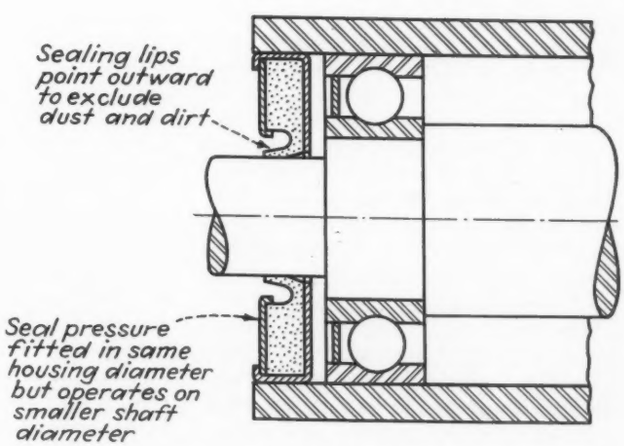

Sealing lips point outward to exclude dust and dirt
Seal pressure fitted in same housing diameter but operates on smaller shaft diameter

Fig.12-Centrifugal Pump Shaft Bearing

RUBBER SPECIFICATIONS

Standardized Tests for Determining Service Life

D. T. BRADLEY

Chief Engineer, Harris Products Company

BECAUSE of manufacturers' reluctance to divulge data on compounding recipes, the user seldom is able to discover for himself what particular type of rubber he is using. Chemical analysis will not ordinarily reveal the original compound. About all that the user can do is to measure certain physical properties and these may or may not be pertinent.

The Durometer reading has been the only standard of hardness or stiffness in common use. However, with this device, two instruments might vary as much as 12 points on the scale or two operators might find variations of several points between their readings on the same sample with the same instrument. In addition, the method of determining hardness by point penetration has been found to be a poor measure of the actual hardness or stiffness as indicated by deflection and torsional tests of finished parts.

Tensile test as a criterion of quality has been found deceptive in that the slabs used are usually laboratory cured and in most cases cured to the point of maximum tensile strength. Actual production parts might be cured to an entirely different point to secure other necessary properties. Thus the tensile value indicates only the maximum which could be secured from the compound under ideal conditions. Of course, elongation varied with tensile.

The permanent set test, as taken from test slabs, indicates only optimum performance, for the same reasons as above. If the permanent set test slabs are furnished with higher cure than the tensile test slabs, test results will be inconclusive. For this reason, it is advisable to take the samples for both tensile and set tests from actual production parts. This can be done readily by turning the part for tensile test on a lathe and by cutting cross-sections for the set test. Such samples are more representative of the actual use condition of the material. Tensile values may be lower than those obtained from test slabs, partly because of the less perfect surface obtained and partly because the cures may be tighter than for slabs.

In our experience, samples cut from the actual production part showed that the load in lb. per sq. in. required to stretch the sample a given percent of the original length was a fairly good indication of the actual stiffness of the part. But the tests also showed considerable variations from the relative hardnesses obtained by Durometer test. It was evident that the two measured somewhat different properties of the material. We then began arbitrarily to specify a value, called the "300 percent modulus"—the load in lb. per sq.in. required to stretch the sample four times its original length. This modulus was found to be quite different in stocks of the same Durometer number but of different composition. Some compounds were called "high modulus" and others "low modulus," depending on the relation between the "300 percent modulus" and the Durometer hardness. This method served to limit the number of compounds which would meet the particular specifications. However, it was slow and destructive, and it only served to indicate how good the piece was which we did not use; nothing was known of those which we did use.

A new instrument designed to replace the Durometer, based on the same general method, but refined to eliminate the variables and inaccuracies inherent in the old design, was developed by the Gogan Machine Corporation. It is a modification of the Brinell hardness tester, adapted to the testing of bushings by actual deflection under load. This equipment is unique in that it employs a magnetic circuit to operate the deflection indicator. Dead weights are used to load the sample, although a similar machine can be made using hydraulic piston loading.

In operation, the part is placed between smooth steel surfaces, and a crank lifts the sample until it supports a minor load of 10 kg. or 22 lb. At this point a contact is closed, and an armature which depends from the indicator is held tightly by a magnet. As the sample is further lifted, a secondary load, varied to suit the part being tested, is also lifted, and the deflection resulting from the application of the secondary load is read. This method eliminates the error caused by the slip of the rubber on the supporting surfaces under small loading, and compensates for the variation in height of the part. The reading taken represents the "rate" of deflection, which is a measure of the true stiffness of the part. The speed of load application has practically no effect upon the result. Variations, however, between the first and succeeding applications, are constant for any particular part and compound, and so may be allowed for. As a standard, the reading on the third loading, after the secondary load has been imposed for 3 sec., is used. For production checking, the first reading may be taken with proper allowances.

After some experimentation, this method has been adopted as a standard to replace the Durometer criterion of stiffness. The SAE-ASTM Joint Technical Committee on Rubber Specifications has done further work on the method and has tentatively established engine mounting stock standards which incorporate a similar method of test, both for use on actual parts and on samples $\frac{1}{2}$ in. x 1 sq.in., cut from slabs. These stocks are to be graded according to this test. Both series of experiments have indicated that for the present a tolerance of plus or minus 15 percent on the deflection of a given sample is commercial. Recent checks have shown that closer control than this is feasible when extra care is used.

In the above test, allowance must be made for the age of the sample. Within the first week after cure, stiffness may increase from 10 to 20 percent. Samples should be rechecked one week after curing. Temperature will also make some difference in certain compounds. It has been found that at 158 deg. F., some stocks will be stiffer and others softer than at room temperatures. With the deflection method for hardness, checks can readily be made on a given stock to determine its properties at elevated and reduced temperatures. This is of importance in many applications where close control on the operating conditions is essential.

Means are thus available for checking the stiffness of the sample, and its resistance to set, in parts actually used. The tensile test is the only remaining

check needed to furnish a criterion which would represent service life. For applications such as compressed rubber joints, for spring shackles, and linkages, where torsion is the most important factor, the tensile strength has, within broad limits, no direct relation to service life.

It was found that some compounds which had the highest tensile failed, while others with lower tensile performed far better. Therefore an oscillation test was set up which duplicated as far as possible the basic use of the material. A spring shackle bearing was loaded to 600 lb. per sq. in., with dead weight load, the eye was oscillated over an included angle of 30 deg. for 18 hours at the rate of 275 r.p.m. Readings were taken of the initial deflection under this load, the maximum deflection at the end of the test, and the "set" after the load was removed. Visual examination determined the type of wear and degree of failure. It was observed that the maximum wear occurred in the first 18 hours, after which little further wear occurred for long periods. Therefore, the 18 hour accelerated test has been adopted as standard, rather than a test run to complete failure.

This test shows variations among compounds which are in no way related to the tensile, elongation, set, or other ordinarily specified properties. It is a measure of the flexing properties, combined with abrasion resistance. The resilience of the stock will, of course, affect the maximum deflection and wear. Thus it serves as a service type test which measures a combination of properties. The rubber is made to do what it is required to do in service and the ability of the material to do so is graded in direct terms. Samples are made to the size of bushings most widely used for shackles, and oscillation tests, set tests and tensile tests, for record purposes, are made from these samples. Specific gravity is also checked.

Since it is not possible to determine the compound used, the problem arises of insuring uniform quality. In general, a check of the specific gravity usually shows up cases of mixed compounds. The actual value of specific gravity is not important, but the amount of variation is.

The greatest variation after compounding is in the cure. Fortunately, an under-cure causes a much greater drop in the stiffness, so the deflection test serves as an excellent check on cure. The set test also indicates this, as the set falls off rapidly with undercure. The set test requires 22 hours.

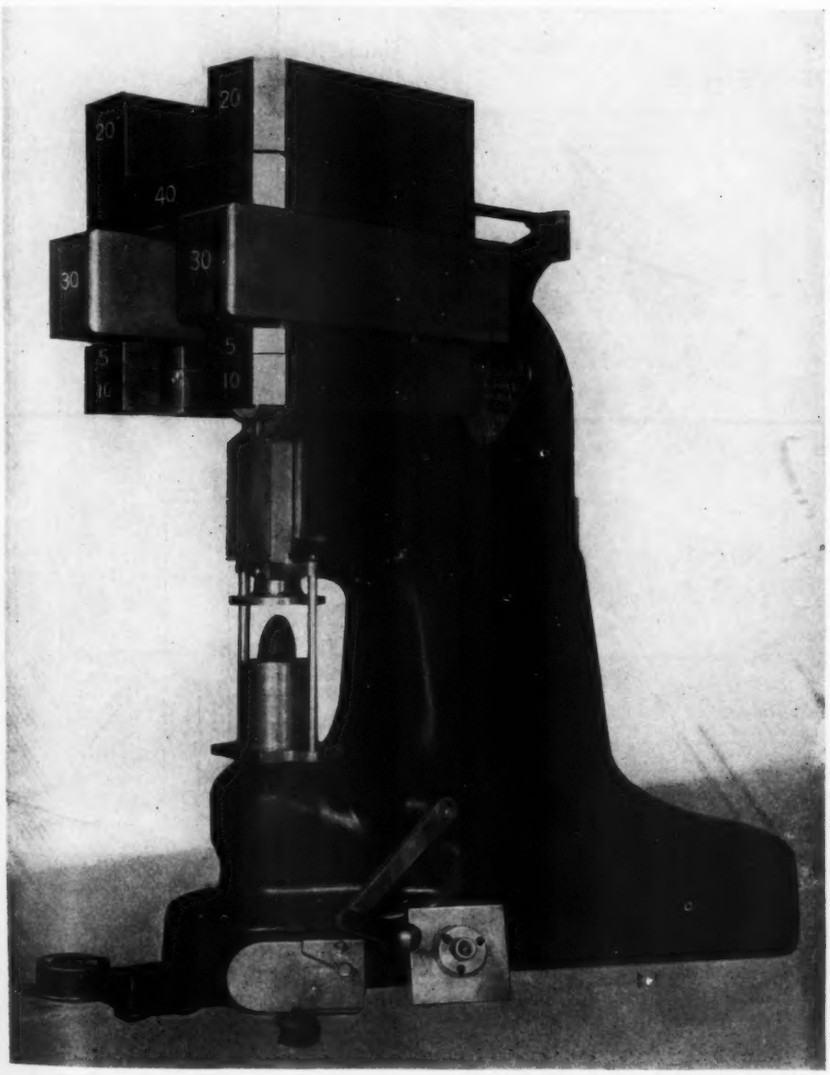
These three checks, together with periodic life tests, should thus serve as good production control procedures, affording much better control than can be obtained by requiring the supplier to furnish at intervals test slabs cured in the laboratory.

The oscillograph, as developed by Dr. Felix Yerzley of DuPont Laboratories, shows promise of adding useful checks on rubber properties. In this test, a load is dropped on the sample and the resilience measured by the height of rebound. The equipment permits of static loading tests, dynamic deflection tests, damping tests, and hysteresis checks. The resilience values obtained have correlated well with the results of Flexometer and heat generation tests.

In arriving at proper stock selection and specification the compound recipe would be of great value to the user. In general, however, some data have been forthcoming regarding the types of compounds used. Compounds such as carbon black, accelerator, and antioxidant, all run to fairly definite classifications, and all affect the result.

In addition, cure variations have to be considered. The test methods suggested have tended to make the compounders confine their efforts to rather definite channels, and have served to aid in securing similar compounds from various suppliers. It is still heresy in some places to mention "soft" and "hard" carbon blacks, and the user will not usually know what type of accelerator has been used, so that specifications must be designed to limit the number of compounds for any particular specification and make each specification cover a definite usage.

It is to be hoped, however, that with the increased cooperation between users and manufacturers in such work as the S.A.E.-A.S.T.M. committee, a more definite type classification will be established and thereby simplify the selection of suitable compounds for given special applications.



Electro-magnetic Gogan rubber compression testing machine

CRANK MECHANISM MOTIONS

New Methods for Their Exact Determination — II

DR. WERNER F. VOGEL
Wayne University, Engineering College

IN THE FIRST of this series of articles, which appeared in June PRODUCT ENGINEERING, the approximate and exact forms of the principal equations of the crank-connecting rod mechanism were presented and constructions of velocity and acceleration curves were shown. In this article will be given greatly simplified equations for the exact computation of motion of this mechanism. In spite of the fact that these equations give exact results, they are easier to compute than are the approximate equations.

Since several references are made to tables and illustrations in Part I, it will be convenient to have June P.E. at hand while following Part II.

Vaes' exact principal equations. By elimination of α and β in Equations (1) to (4) one can get a direct relationship between displacement, velocity and acceleration of the piston. This was the way F. J. Vaes derived his form of principal equations. In order to simplify his formulas he measured the displacement not from the head-end dead center D_o, but from the center M of the crank. If, as in Fig. 11, we call this displacement ξ, we obtain, with our symbols, the exact principal equations in the following forms:

$$c = \omega \sqrt{\frac{4\,\xi^4\,l^2}{(\xi^2+f^2)^2} - \xi^2} \qquad (10)$$

$$a = \omega^2 \left(\xi - \frac{8\,\xi^3\,f^2\,l^2}{(\xi^2+f^2)^3} \right) \qquad (11)$$

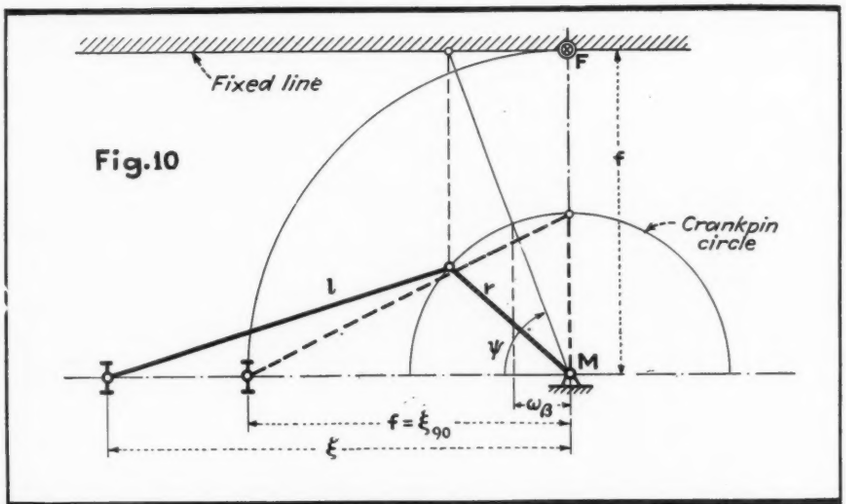
Hence, the slope of the acceleration-curve is found to be as follows:

$$\tan\,\delta = \frac{da}{dx} = -\frac{da}{d\xi}$$

$$\tan\,\delta = -\,\omega^2 \left(1 - \frac{24\,\xi^2\,f^2\,l^2\,(f^2-\xi^2)}{(f^2+\xi^2)^4} \right) \qquad (12)$$

Equations (10) to (12) are taken from the excellent treatise by Vaes in which they are utilized for a complete and thorough analysis of the crank mechanism. Vaes' analysis can be found in the treatise "Etude Mathematique due la Transmission par Bielle et Manivelle" which appeared in *Extrait des Annales de l'Ecole Polytechnique de Delft, Tome VIII*, pg. 114–192, published by E. J. Brill, Leiden, Netherlands, 1897, which is the French translation of the original written in Dutch, published in *Tijdschrift van het Koninklijk Institut van Ingenieurs*, 1890–91, pg. 63–80 and 1891–92, pg. 52–58. Unfortunately, this outstanding treatise has been until now almost entirely unknown in American, English, and German engineering literature.

The above equations by Vaes use the piston's displacement as the initial value. Thus there is a hint that their application may be especially advantageous in the case frequently occur-



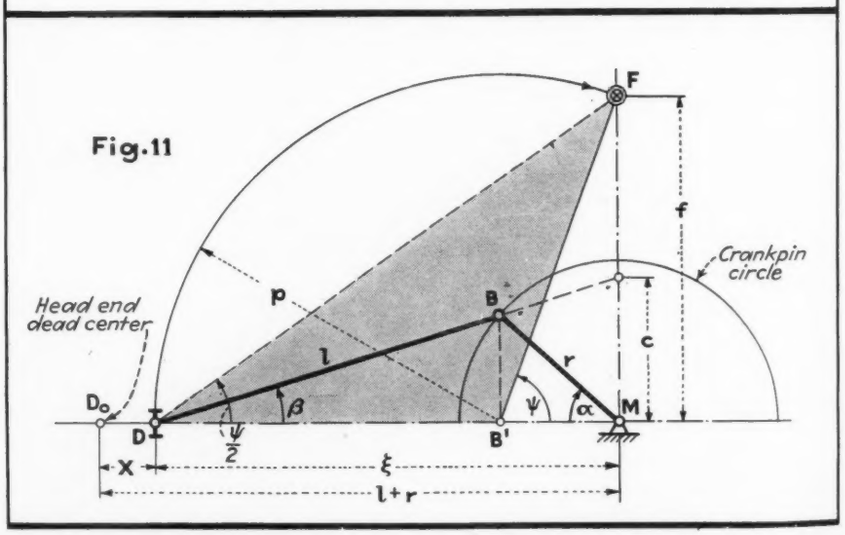


Fig. 10—Method of locating the Fixed Point F with respect to 90 deg. position of the crank, thus graphically obtaining Ψ and ω_β. The scale of the connecting rod angular velocity ω_β is established by letting length r represent ω of the crank.

Fig. 11—The triangle FB'D is always isosceles. The simple Equations (14), (15) and (16) can be read directly from the figure. The scale of piston velocity c is established by letting the length r as drawn represent $r\omega$ of the crank

ring wherein the piston's displacement is the given magnitude. For practical numerical computations, however, a transformation of Vaes' formulas, developed below, will permit an even simpler calculation.

Simplified exact equations. New computing method based on the author's discovery that every crank mechanism has a geometrical fixed point *F*, the significance of which is explained in Figs. 10 to 14. If we designate ψ the angle, as in these figures, then we can show all magnitudes to be computed as simple functions of this new variable only. This exact method of computation is given for the first time in Tables IV and VI. It may be noted that if we substitute for tan β in Table VI,

$$\sqrt{\left(\frac{\sin\psi}{\lambda_f}\right)^2 - 1} \quad ,$$

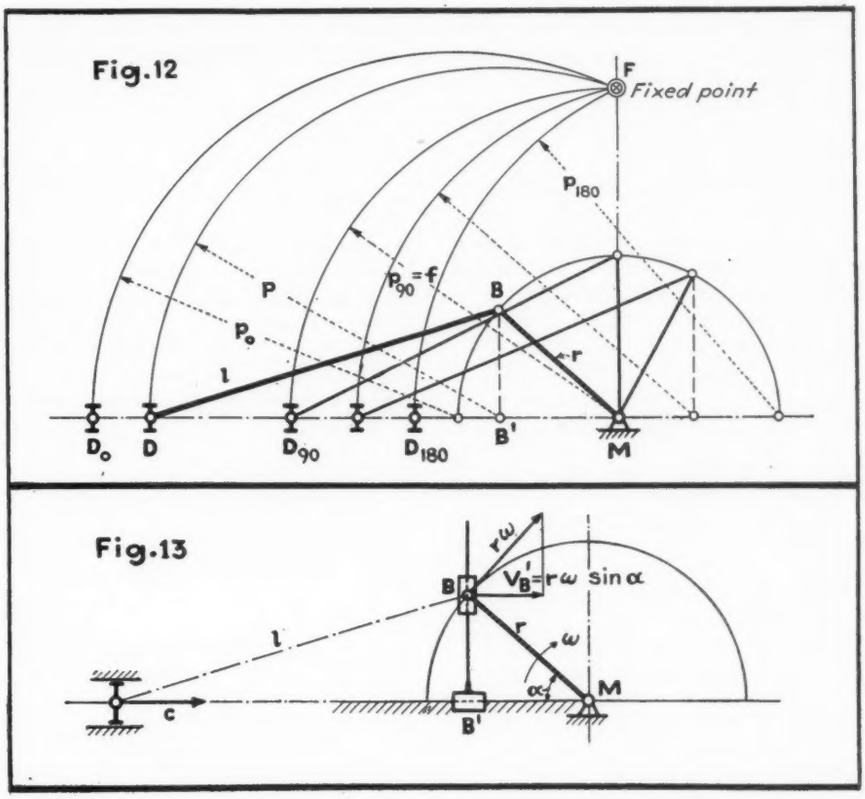
the only independent variable is the parameter ψ. This substitution, however, would decrease the simplicity of the formulas.

The simple relation between the new independent variable ψ and the former one α is shown in Fig. 15 while Equations (13) to (22) of Table VI illustrate the shortest way of computation. Also for the slope of the acceleration curve we get now a less involved equation:

$$\tan\delta = \frac{da}{dx}$$

$$= -\omega^2\left[1 + 3\left(1 - \frac{a}{\xi\,\omega^2}\right)\cos\psi\right] \qquad (23)$$

The new form of expression of the principal equations has the further advantage over the formulas in Tables II and III in that each value determining the position of the mechanism can be utilized immediately as the



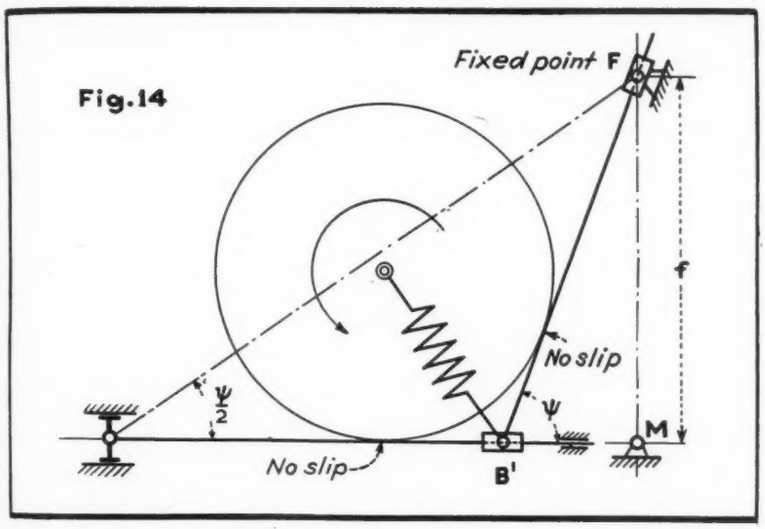


Fig. 12—All of the circular arcs pass through point F. The centers of these arcs are at the vertical projection of the crankpin center upon the horizontal, such as the center B'. The arc radii are the length of the projection of the connecting rod upon the horizontal, for the corresponding crank and rod positions (example: radius p = B'D)

Fig. 13—Velocity of slider B' moving with simple harmonic motion, is the horizontal component $v_B' = r\omega \sin\alpha$ of the crankpin velocity. The different velocity c of the piston is caused by additional motion of the connecting rod

Fig. 14—Equivalent isosceles mechanism for analysis of motion replaces the connecting rod of Fig. 13. Piston moves in the same way as in Fig. 13, if slider B' is given the previous motion

Table IV—Constants of Crank Mechanism

Notation	Symbol	Equation	Illustration
Connecting Rod Ratio.....	λ	$\lambda = \frac{r}{l}$	
Distance of Fixed Point.....	f	$f = \sqrt{l^2 - r^2} = l\sqrt{1 - \lambda^2}$	Figs. 10-12
Ratio of Fixed Point.....	λ_f	$\lambda_f = \frac{f}{l} = \sqrt{1 - \lambda^2}$	
Radius of Auxiliary Circle 1...	R_1	$R_1 = \frac{f^2}{l} = l\,\lambda_f^2$	Figs. 16-17
Radius of Auxiliary Circle 2...	R_2	$R_2 = \frac{l^2}{f} = \frac{l}{\lambda_f}$	Fig. 18

initial magnitude. For instance, if the displacement of the piston is the given magnitude, then the new method is even simpler than the approximate equations of Table II. The following examples illustrate the procedure:

PROBLEM 1. For an airplane motor of 3,000 r.p.m. the radius of the crank is $r = 0.21$ ft. and the length of the connecting rod is $l = 0.7$ ft. The acceleration of the piston at 20 percent of its stroke is required.

SOLUTION:

Constants of Mechanism:

$$f = \sqrt{l^2 - r^2} = \sqrt{0.7^2 - 0.21^2} = 0.66776 \text{ ft.}$$

$$R_2 = \frac{l^2}{f} = \frac{0.49}{0.66776} = 0.73380 \text{ ft.}$$

$$\omega = \frac{\pi n}{30} = \frac{3{,}000\pi}{30} = 314.16 \text{ rad/sec.}$$

Piston Displacement:

$$x = 0.20 \times 2r = 0.20 \times 2 \times 0.21 = 0.084 \text{ ft.}$$
$$\xi = r + l - x = 0.21 + 0.7 - 0.084 = 0.826 \text{ ft.}$$

Angle of Fixed Point's Ray:

$$\operatorname{cotan} \frac{\psi}{2} = \frac{\xi}{f} = \frac{0.826}{0.66776} = 1.2370$$

$$\frac{\psi}{2} = 38^\circ\ 57'\ 11''$$

$$\psi = 77^\circ\ 54'\ 22''$$

Piston's Acceleration:

$$a = \omega^2 (\xi - R_2 \sin^3 \psi)$$
$$= (314.16)^2 (0.826 - 0.73380 \sin^3 77^\circ\ 54'\ 22'')$$
$$= 13{,}817 \text{ ft./sec.}^2$$

Table V—Slope of the Motion Curves

Slope	Plotted against piston displacement x	Plotted against crank angle α
Velocity curve.....	$\tan \gamma = \frac{dc}{dx} = \frac{dc}{dt} \cdot \frac{dt}{dx} = \frac{a}{c}$	$\tan \sigma = \frac{dc}{d\alpha} = \frac{dc}{dt} \cdot \frac{dt}{d\alpha} = \frac{a}{\omega}$
Acceleration curve.....	$\tan \delta = \frac{da}{dx} = \frac{da}{dt} \cdot \frac{dt}{dx} = \frac{j}{c}$	$\tan \tau = \frac{da}{d\alpha} = \frac{da}{dt} \cdot \frac{dt}{d\alpha} = \frac{j}{\omega}$

The values a, c and j may be taken from Table II (June P.E.) or Table VI
For $\tan \delta$ use final Equations (6) or (12) or (23)

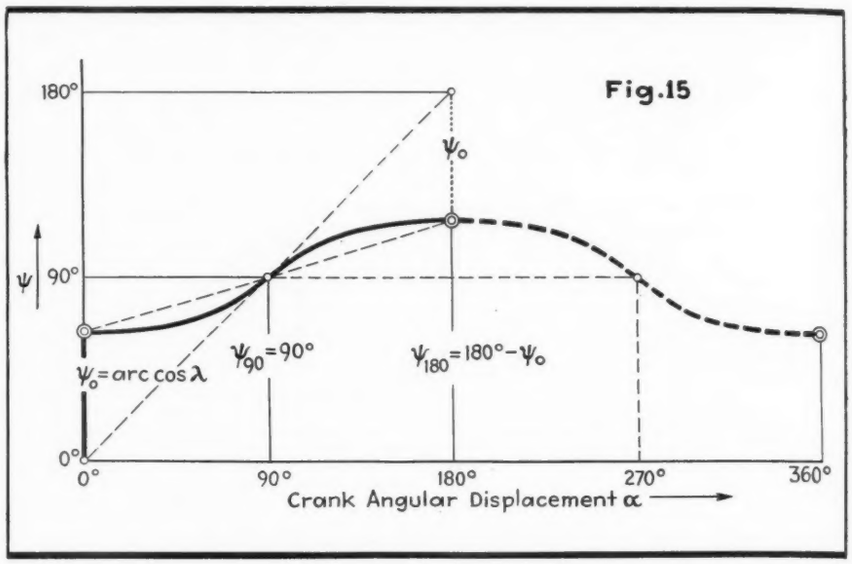


Fig. 15—Typical ψ—α diagram. See Figs. 10 and 11 and Equation (13) in Table VI. Limiting dead center values ψ_0 and ψ_{180} are given by cos $\psi_0 = \lambda$ and cos $\psi_{180} = -\lambda$

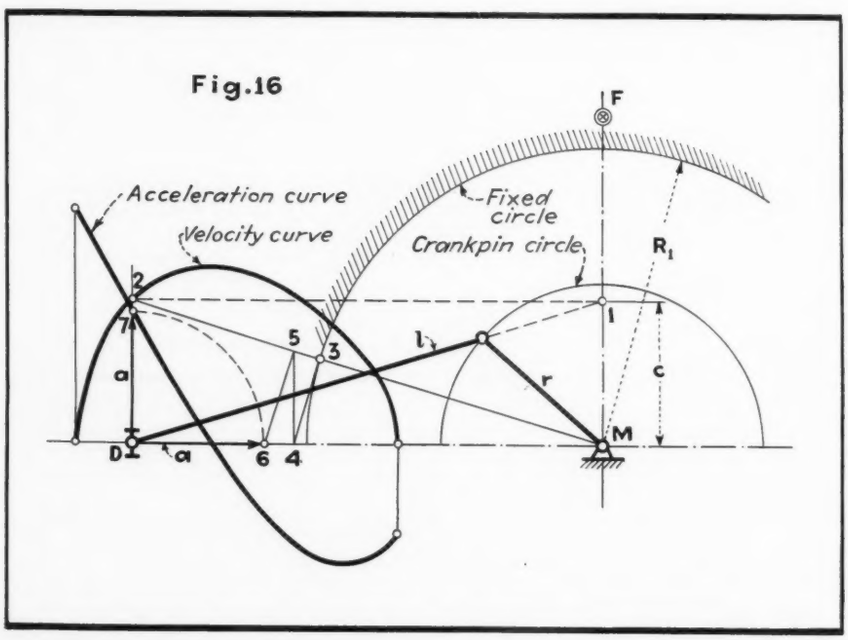


Fig. 16—New graphical construction for obtaining the piston acceleration. For the magnitude of R_1 see Table IV. The numbers indicate the successive steps in the construction. The method shown here uses the fixed circle of radius R_1 and the auxiliary lines 3-4, 4-5, 5-6 are perpendicular to either M-2 or M-D

Note: For comparison try the solution by using one of the former methods as given in Table II.

PROBLEM 2. Using the data of Problem 1, one may compute the position and angular motion of connecting rod.

Angular Displacement:

$$\cos \beta = \frac{f}{l \sin \psi} = \frac{0.66776}{0.7 \sin 77^\circ\ 54'\ 22''}$$
$$= 0.97560$$
$$\therefore \beta = 12^\circ\ 41'\ 0''$$

Angular Velocity:

$$\omega_\beta = -\omega \cos \psi = -314.16 \cos 77^\circ\ 54'\ 22''$$
$$= -65.82 \text{ rad/sec}$$

Angular Acceleration:

$$\epsilon_\beta = \omega^2 \sin^2 \psi \tan \beta$$
$$= (314.16)^2 \sin^2 77^\circ\ 54'\ 22'' \tan 12^\circ\ 41'$$
$$= 21{,}237 \text{ rad/sec}^2$$

PROBLEM 3. Using the data of Problem 1, the velocity of the piston and the position of the crank can be computed.

Velocity of the Piston:

$$c = \xi \omega \tan \beta$$
$$= 0.826 \times 314.16 \tan 12^\circ\ 41'$$
$$= 58.40 \text{ ft/sec}$$

Table VI—Simplest Exact Formulas for Practical Computations

Part of Mechanism	Value	Symbol	Equation	No.
Crank	Angular Displacement	α	$\cos\alpha = \frac{f}{r}\,\text{cotan}\,\psi$	(13)
Crosshead and Piston	Displacement	ξ	$\xi = f\,\text{cotan}\,\frac{\psi}{2}$	(14)
		x	$x = l + r - \xi$	(15)
	Velocity	$c = \frac{dx}{dt}$	$c = \xi\,\omega\tan\beta$	(16)
	Acceleration	$a = \frac{dc}{dt}$	$a = \omega^2(\xi - R_2\sin^3\psi)$	(17)
			$= \omega^2\left(\xi - \frac{R_1}{\cos^3\beta}\right)$	(18)
	Increase of Acceleration	$j = \frac{da}{dt}$	$j = -\omega^2 c\left[1 + 3\left(1 - \frac{a}{\xi\,\omega^2}\right)\cos\Psi\right]$	(19)
Connecting Rod	Angular Displacement	β	$\sin\beta = \lambda\sin\alpha$	(2)
			$\cos\beta = \frac{f}{l\sin\psi} = \frac{\lambda_f}{\sin\psi}$	(20)
	Angular Velocity	$\omega_\beta = \frac{-d\beta}{dt}$	$\omega_\beta = -\omega\cos\psi$	(21)
	Angular Acceleration	$\epsilon_\beta = \frac{d\omega_\beta}{dt}$	$\epsilon_\beta = \omega^2\sin^2\psi\tan\beta$	(22)

$\omega = \frac{\pi n}{30}$ is the constant angular velocity of the crank.

For constants f, λ, λ_f, R_1, and R_2 of the mechanism see Table IV.

The heavily framed equations are the Principal Equations.

Select the independent varibale ψ between the values ψ_0 and ψ_{180} of the dead-centers given by the equations: $\cos\psi_0 = \lambda$; $\cos\psi_{180} = -\lambda$

Angular Displacement of Crank:

$$\cos\alpha = \frac{f}{r}\,\text{cotan}\,\psi$$

$$= \frac{0.66776}{0.21}\,\text{cotan}\,77^\circ\,54'\,22''$$

$$= 0.68133$$

$$\alpha = 42^\circ\,57'$$

Checking α by Equation (2) gives the same result.

PROBLEM 4:

Some points of the acceleration-displacement diagram are to be computed for the crank mechanism given in Problem 1.

SOLUTION:

For the dead centers find:

$$\cos\psi_0 = \lambda = 0.3\,;\ \psi_0 = 72^\circ\,30'\,33''$$

$$\psi_{180} = 180^\circ - \psi_0 = 107^\circ\,29'\,27''$$

We are entirely free to select the variable ψ between these values; however, it simplifies the computation if every obtuse angle is chosen as a supplement of one of the selected acute angles.

With $f = 0.66776$ ft., $r + l = 0.28$ ft., and $\omega = 314.16$ rad/sec. (from Problem 1) the procedure of computation is as shown in the accompanying tabulation on page 378.

NOTE: The x and a values for $\alpha = 0°$, 90° and 180° may be easily checked by using the special formulas of Table VII.

Tangents of curves of motion. The slope of the "undistorted" curves of motion is given in the exact equations of Table V. Because the values plotted on the abscissas and ordinates of the motion curves are of different dimension, the curves are "undistorted" only if the same scale is selected for both the unit of the abscissas and the unit of the ordinates. If the scales are not the same, the curves are distorted. Fig. 1, for instance, is undistorted, while in Fig. 5 the ordinates have only half of the scale necessary for this purpose. The motion curves over α in Fig. 2 would be undistorted if we would have selected the distance W_0W_{360} equal to the circumference of the crank-pin circle.

Curves of motion obtained by graphical construction are usually undistorted while this does not generally hold true for semi-graphical constructions.

For distorted curves, a factor must be used for converting the slope calculated into the slope of the curve. This applies to every equation for the slope of the curves of motion presented.

Fortunately, such numerical evaluation is seldom needed in practical cases. The worth of the formulas is

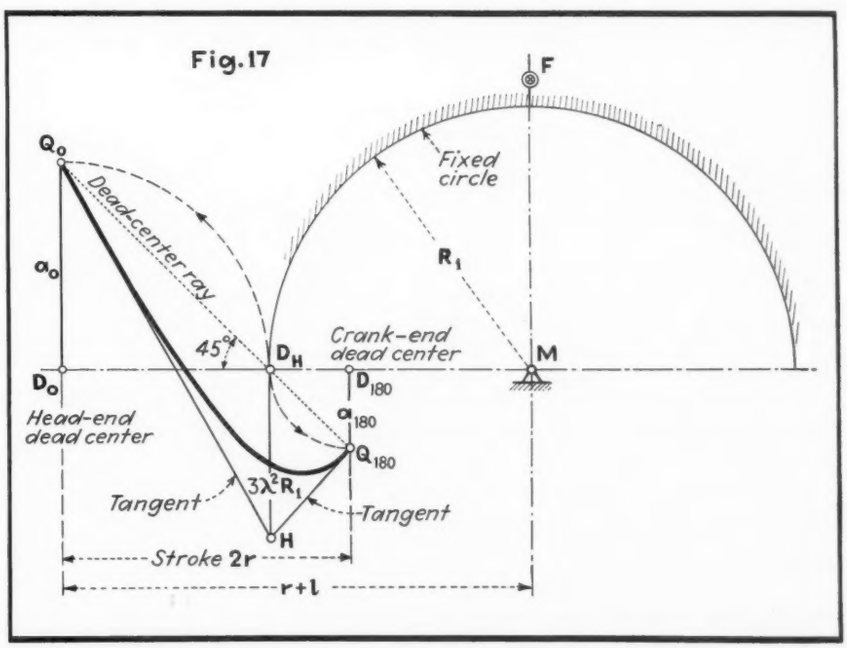


Fig. 17—Application of graphical method shown in Fig. 16 to the dead-center positions. Dashed circles can be replaced by dotted straight line (dead center ray). For computations see Table VII. Note change of scale in checking constructions

Table VII—Special Positions of Crank Mechanism

Values of piston displacement and acceleration computed by the formulas in this table are used for the simplified construction of the acceleration curve, as in Fig. 4. The value of λ_f is computed from $\lambda_f = \sqrt{1 - \lambda^2}$

Position of Mechanism	Crank Position α in deg.	Piston		Slope of $a \ldots x$ Curve	Piston Velocity
		Displacement	Acceleration		
Head Dead Center — D_0	0	$x_0 = 0$	$a_0 = r\,\omega^2\,(1 + \lambda)$	$\tan\,\delta_0 = -\omega^2\left(1+3\,\lambda\,(1-\lambda)\right)$	$c_0 = 0$
90 deg. Position	90	$x_{90} = r\left(1 + \frac{1-\lambda_f}{\lambda}\right)$	$a_{90} = -\,r\,\omega^2\,\frac{\lambda}{\lambda_f}$	$\tan\,\delta_{90} = -\,\omega^2$	$c_{90} = r\omega$
Crank Dead Center — D_{180}	180	$x_{180} = 2\,r$	$a_{180} = -r\,\omega^2\,(1-\lambda)$	$\tan\,\delta_{180} = \omega^2\left(1 - 3\,\lambda\,(1+\lambda)\right)$	$c_{180} = 0$

based rather on their applicability for deeper analysis and on the fundamental general results already obtained by such methods.

For a speedy and exact tracing of the a–x curve of acceleration, the special positions of the mechanism, shown in Table VII, are of immediate practical importance. The following statement can be made concerning the tangents of the motion curves in these positions:

a–x Velocity Curve Figs. 1 and 19.

1. At the dead centers D_0 and D_{180} the c–x curve always has vertical tangents.

2. For the 90 deg. position of the crank, $\alpha = 90$ deg., the c–x curve's tangent at P_{90} always passes through M, the crank center.

a–x Acceleration Curve Figs. 1, 17, 19.

3. The location of the dead-center ray Q_0Q_{180} and of its intersecting point D_H with the X-axis influences decisively the shape of the a–x curve. See Fig. 17.

4. The tangents at the dead-center points Q_0 and Q_{180} on the a–x curve intersect each other at a point H, which is always located on a vertical line through D_H. See Figs. 4 and 17.

The location of H can be easily computed from $HD_H = h$.

$$h = 3(\lambda - \lambda^3)\,r\,\omega^2$$

5. For the 90 deg. position of the crank, $\alpha = 90$ deg., the tangent to the a–x-curve at Q_{90} always is parallel to the dead-center ray. See Fig. 4.

For an undistorted a–x curve the ray and tangent intersect the x-axis always at −45 deg. See Figs. 1, 17 and 19.

Above statement 4, given here for the first time, is noteworthy in that it is valid even in cases where the a–x curve of acceleration has one or two points of inflection. The extremely simple graphical constructions shown in Figs. 17, 19, and 4 are the application of the relationships expressed in statements 3 to 5, given above.

Other applications of the slope equa-

Tabulating Calculation for Problem 4

Select the obtuse angles ψ as supplements of the acute values

α	ψ	$\xi = \text{f. ctg}\,\frac{\psi}{2}$	$x = r + l - \xi$	$a = \omega^2\,(\xi - R_2 \sin^3\psi)$
0	72° 30′ 33″	0.91 ft.	0 ft.	26944 ft./sec.²
	75°	0.87024	0.0398	20622
	80°	0.79581	0.1142	9371
	85°	0.72874	0.1813	326
90°	90°	0.66775	0.2423	− 6519
	95°	0.61189	0.2981	− 11207
	100°	0.56031	0.3497	− 13872
	105°	0.51239	0.3976	− 14696
180°	107° 29′ 27″	0.49000	0.4200	− 14508

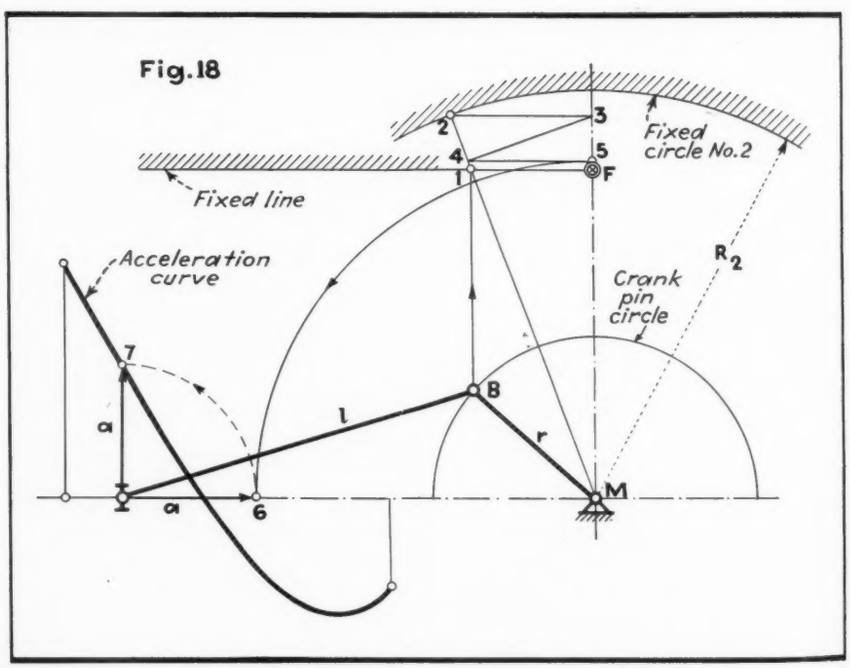


Fig. 18—A second new method of graphical construction uses the fixed circle R_2 in order to obtain the piston acceleration. For the magnitude of R_2 see Table IV. Auxiliary lines 2-3, 3-4, 4-5 are perpendicular to either M-F or M-2

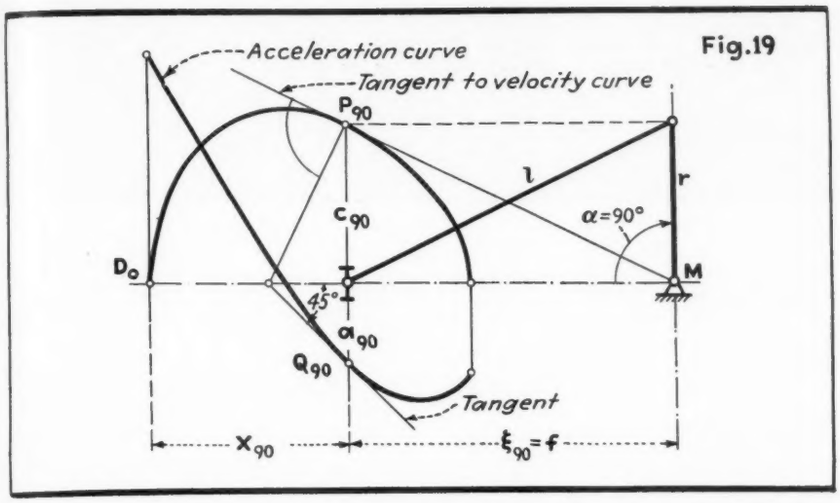


Fig. 19—Simple graphical construction for the 90-deg. position. This construction gives directly the values of c_{90} and a_{90} as well as the coordinated tangents of the curves of motion. See Table VII for the equations to compute the quantities c_{90} and a_{90}

tions will be found in the sections investigating maxima, minima, and points of inflection of the curves of motion.

Graphical solutions. Graphical methods may be used to replace or to check computations. A characteristic of all graphical methods is the circumstance that the constructions can be made without paying any attention to the angular velocity ω of the crank. Only after having finished the geometrical construction does the magnitude of ω have to be considered, namely when fixing the scales of the required values.

The needed scales always will bear a simple relation to the drafted length of *r*, the crank radius. Thus, for example, in Fig. 10 a simple graphical construction for the angular velocity ω_β of the connecting rod is shown. The scale of ω_β is determined after completing the graph by having the length of the crank radius as drawn equal ω, the angular velocity of the crank.

In Fig. 16 the ordinate *c* is the measure of the piston velocity *c*. In order to get *c* in feet per second we have to introduce a scale determined by designating *r*ω of the crank equal to the length of the crank radius *r*, as drawn. This well-known construction can be seen in almost all engineering manuals.

Much less known, unfortunately, is Mohr's graphical construction of the piston acceleration, Fig. 1. In the length *MN* we find the vector of the acceleration *a* for the selected position of the mechanism. The scale for this vector is given by the relationship that $r\omega^2$ of the crank is equal to the length of the crank radius as drawn.

Two new graphical constructions for the acceleration, based on the exact Equations (18) and (17), respectively, are given for the first time in Figs. 16 and 18. Each employs a fixed circle, the radii of which, R_1 and R_2 are different from each other. See Table IV. The scales in both of the designs are the same as in Mohr's construction; contrary to Mohr's, the new methods allow a construction also for the dead-center positions of the mechanism; Fig. 17 shows this construction.

The graphical methods, shown in Figs. 17 and 19, are for those special points, Q_0, Q_{180}, and Q_{90}, of the *a–x* curve of acceleration, which correspond to the dead-center positions and to the perpendicular position, $\alpha = 90°$, of the mechanism. These constructions, giving at the same time the tangents at Q_0, Q_{180}, and Q_{90}, are extremely simple. In the range of the most usual cases, $\lambda < 0.39$, the *a–x* curve has no point of inflection, and these three tangents determine the character of the *a–x* curve. In this range the three tangents together with the dead-center ray incorporate the "circumscribed polygon" of the *a–x* curve, as in Fig. 4, which fixes the shape of the curve so accurately that often it may be unnecessary to determine any further points.

Semi-Graphical Methods. For greater convenience and accuracy it is advisable to make the constructions of the true tangents at Q_0, Q_{180}, and Q_{90} applicable to semi-graphical constructions, which do not need the drawing of the crank center. A further advantage of these methods is that one is entirely free in the selection of all scales so that the utilization of commercial coordinate paper (cross-section paper) and the direct use of their printed scales is possible.

In Fig. 4 is shown the semi-graphical design of the circumscribed polygon of the true *a–x* curve. Only a few easy computations are necessary to find the inscribed values for constructions. In many cases, especially for $\lambda < 0.4$, the two tangent-constructed parabolas Q_0Q_{90} *and* $Q_{90}Q_{180}$, shown in Fig. 4, may alone give sufficient accuracy, though they are only approximations of the true *a–x* curve.

When greater exactness is needed or when points of inflection occur, as in the range $\lambda > 0.4$, additional exact points of construction, as will be shown in Part III, may be preferred to the described approximate construction.

Editor's Note: The following corrections are to be noted in Part I of the June issue of Product Engineering. In Equations (6) and (6A) of Table II the symbol ϑ should be changed to δ. In Equation (6A) the symbol λ should precede *cos* α in the denominator.

In Fig. 1 the two equal areas referred to in the last line of the caption as shaded, are the two areas between the x-axis and the acceleration curve $(Q_0 - Q^* - S^{**} - Q_{180})$, the one above the horizontal axis and the other below.

Table III is repeated here to indicate that β is a subscript rather than a multiple of ω and ε.

Table III—Equations for the Angular Motion of Connecting Rod

	Symbol	Equation	No.
Connecting Rod Angular Displacement.....	β	$\sin\beta = \lambda \sin\alpha$	(2)
Connecting Rod Angular Velocity.....	$\omega_\beta = \frac{-d\beta}{dt}$	$\omega_\beta = -\omega\,\lambda\,\frac{\cos\alpha}{\cos\beta}$	(7)
		$= -\omega \operatorname{cotan}\alpha \tan\beta$	(8)
Connecting Rod Angular Acceleration.....	$\epsilon_\beta = \frac{d\omega_\beta}{dt}$	$\epsilon_\beta = (\omega^2 - \omega_\beta^2)\tan\beta$	(9)

The positive sign signifies clockwise rotation like that of the crank.

Question and Comment

Total Load on Bolts

RANSOM S. THOMPSON
Chief Engineer, Woodbury Machine Company

In the "Question and Comment" section for May, 1941, page 263, there appeared a discussion on "Total Load on Bolts" by Walter M. Haessler of the American Car & Foundry Company.

As Mr. Haessler's treatment of this problem is the first rational one I have seen in print, I believe some further discussion of the matter is very much in order. The fundamental equation (1) developed by Mr. Haessler:

$$T = \left(\frac{\beta}{\alpha + \beta}\right) W + C_i$$

where

T = Total bolt tension
C_i = initial tension on bolt
α = elastic extension of bolt per unit load
β = elastic compression of plate per unit load
W = load applied

is identical in meaning with the one which I have worked out and have used for years in the solution of problems of this type. As I have considered a tightened bolt as an extension spring and the material on which the bolt is tightened as a compression spring, my own equation includes the values K_t for the spring rate of the bolt in pounds per inch and K_c for the spring rate of the compression member:

$$T = C_i + \left(\frac{K_t}{K_t + K_c}\right) W$$

Since the symbols K_t and K_c are in units of pounds per inch, they are really the reciprocal of Mr. Haessler's α and β respectively (α and β being in units of inches per pound) and the two equations are really the same. Further, the three deductions (a), (b) and (c) derived from this equation by Mr. Haessler in his discussion are correct with the exception of the very minor point that deduction (a) should read "If $\beta = 0$, then $T = C_i$ *or* W, whichever is the greater, because the bolt tension will exceed the screw-up load if the applied load is greater than the initial tightening load."

Despite our perfect agreement up to this point, I am forced to disagree with Mr. Haessler on every one of the items mentioned in his further discussion on the subject:

(1) Under the same load conditions, a "necked-down" bolt will be subject to greater stresses than a bolt with a full shank.

(2) The bolts in the "big end" of conting rods are necked down in order to place the bolt resiliency where it will do the least harm and not in an attempt to reduce the total stress.

(3) Long bolts give no better condition than short ones if the type of loading is the same in both cases and if the relative resiliency of the threaded sections of the bolts is the same in both cases.

(4) The improvement in the life of the jackhammer cylinder head bolts after the adoption of long bolts was due to the difference in the relative resilience of the threaded and unthreaded sections of the different bolts.

The matter of the stress in necked-down bolts can best be seen by an example. In tightening bolts that are subject to the type of working load herein considered, it is customary to use a tightening load at least 50 percent greater than the working load. If a full shank bolt is tightened to this stress against a compression member whose area is equal to that of the bolt (and of the same material) we have the following load condition:

$$T = C_i + \left(\frac{\beta}{\alpha + \beta}\right) W$$

$$= \frac{3W}{2} + \frac{W}{2} = 2\,W$$

and the stress is $2W/A$, where A is the cross-sectional area of the bolt. If the bolt is now necked down until its cross-section area is $0.8A$, so that $\alpha = 1.25\ \beta$, the following conditions result:

$$T = \frac{3W}{2} + \frac{W}{2.25} = 1.944\,W$$

and stress is $1.944W/0.8A = 2.43\ W/A$.

In practice, the area of the compression member is usually much greater than that of the bolt, so it will be well to investigate that condition. To take an extreme example, let $\alpha = 9\ \beta$. Now, for the full-shank bolt:

$$T = \frac{3W}{2} + \frac{W}{10} = 1.60\,W$$

and the stress is $1.60\ W/A$.

For the necked-down bolt, $\alpha = 11.25\ \beta$, and

$$T = \frac{3W}{2} + \frac{W}{12.25} = 1.5816\,W$$

and the stress is

$$\frac{1.5816\,W}{0.8\,A} = 1.977\,\frac{W}{A}$$

It is noteworthy that no expression for bolt length appears in any of the above calculations. In such applications as connecting rod "big-end" bolts and cylinder head through-bolts, the stressed length of the bolt is equal to the stressed length of the compression member and their relative spring rates are dependent only on their relative cross-sections and their materials. Thus, a short bolt properly designed and applied is fully as satisfactory as a longer one.

The design of bolts for connecting rod "big ends" is a complicated problem, but the reason that they are necked down can be explained as follows: any bolt subjected to repeated stress is subject to tensile fatigue failure at that section which stretches most under the applied load. A full-shank bolt will concentrate most of its flexure in the weak section at the root of the thread and may soon fatigue at that point. By necking down the bolt the flexure of the bolt is distributed over the shank, which is more able to resist fatigue failure than the sharp notch of the thread.

The case of the jackhammer cylinder head bolts is somewhat analogous. The short bolts were not subjected to any higher stresses than the long bolts, but the short bolts offered very little resilience except at the root of the threads.

Running Around In Circles

To the Editor:

I wonder if some of your readers would be interested in deriving formulas that will give correct answers to

the questions proposed below. The answers are in dispute here.

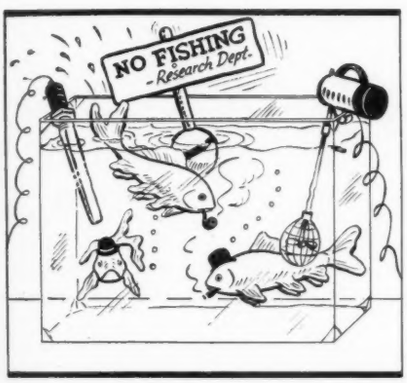
An automobile is running at a speed of n m.p.h. round a circular highway of radius d ft. (d ft., that is, from the center of the circle to a point halfway between the two rear wheels). What is the angular speed in r.p.m. of each rear wheel relative to:

(a) the ground,
(b) the chassis of the car,
(c) the other rear wheel?

What, moreover, is the angular speed of the engine relative to the chassis, assuming that the engine is directly connected to the drive shaft? To avoid unnecessary complication assume (1) that the roadway is not banked and (2) that the center line of the rear axle remains perpendicular to the circle that any point on the center line describes.

Exact, not approximately correct, formulas are desired.

—William H. Rasche
Virginia Polytechnic Institute



Grim Reaper Overtakes G. E. Goldfish

To the Editor:

Death, as it must to all fish, came on May 28 to the last of the three famed goldfish who worked for a living in the laboratory of the General Electric plastics department at Pittsfield, Mass. Death was attributed to loneliness.

A year ago, the three goldfish became "employees" of the General Electric Company when it was found they could adequately save seven hours a week of a man's time by devouring the algae which accumulated on the sides of a viscosity measuring bowl and which prevented chemists from watching reactions. (P.E. Nov. 1940, p. 503).

After five months of faithful duty, goldfish No. 1 contracted a mysterious disease which caused "brown spots" and finally death. The death of No. 2 was more harsh. He got caught in a pipe leading from the bowl, injured his back and "came to the top." No. 3 died of loneliness.

Dr. G. F. D'Alelio has made known that the fish will be replaced when the new G.E. plastics laboratory at 1 Plastics Avenue, Pittsfield, Mass., is completed this summer. —K. G. Patrick
General Electric Co.

Adhesives "Custom Built" For Cementing Fabrics

[*Editor's Note*—In our article "Fastening Methods for Flexible Sheet Materials" (P.E. June 1941, p. 316–317), we dismissed adhesives by stating that examples of their application were too commonplace to deserve much space. Since then, we've received several letters from men acquainted with problems of adhesives. In general, they agreed with us, adding the comment that each "stickum" problem must be treated individually. They seemed to feel that a little general information would be better than nothing, so here it is—excerpts from two letters.]

To the Editor:

An example of adhesion of cloth to felt is the grosgrain ribbon on edges of hat brims. A fusible resin composition is dissolved in a quick-drying solvent, applied to the felt and permitted to dry. the ribbon is then bonded to the brim with heat and pressure. The cement solution should have high viscosity so that penetration will be negligible.

A wide variety of lacquer cements are used for attaching cloth to leather, glass, metal, cellulose-acetate sheets, wood. These cements generally have the disadvantage of being inflammable and the great advantage of being waterproof.

Recent patents cover the manufacture of completely opaque window shades which are laminated of textile and metal foil. This bonding process is carried out with permanently plastic resin compositions which are applied from solution and allowed to dry to a highly tacky condition before the sheets are pressed together. —William M. Lee
The Arabol Mfg. Co.

To the Editor:

There are several types of adhesives available for fastening flexible sheet materials. These are either of a vegetable, cellulose or rubber base. Vegetables glues are soluble in water, and generally are used where waterproofing is not essential and where low-cost is desired.

Cellulose glues are made from nitrocellulose or cellulose-acetate base and are used for transparent wrapping, leather cements, and cements for plastic and metal. Some plastics can be glued with a rubber-base cement, depending on how long the adhesion must hold.

These adhesives are usually modified to fit the method of application, production speed, drying time required, materials, strength required, and other considerations of the individual concern, particularly where production is large. It is usually necessary to "custom build" each adhesive for best results.

—I. A. Schulist
Midland Glue Products Company

"Collar Button" Fastener

To the Editor:

Sheet rubber is often fastened to other materials by a fastener which is very similar to a collar button. The buttonhole in the rubber is smaller than the head of the fastener, and is stretched over the head. This operation, unlike putting on a starched collar, can be performed quite easily without the aid of grunts and expletives.

—Allen F. Clark
Rubber Chemicals Div.
E. I. Du Pont de Nemours & Company

Can You Work This One?

H. E. SMITH

Solution to June problem—

Call for Mr. Archimedes!

A large ice cube is floating in a glass just full of water. When the cube melts, the level of the water will remain exactly the same. Reason for this is really quite simple. Bodies floating in water displace their own weight, hence when the ice melts the volume of water from the cube will be equal to the volume of that part of the ice cube which is under the surface. Eureka!

This month's problem—

How Many Widgets?

A manufacturer seeking sub-contractors for widgets contacts A, B, C, and D. Company A agrees to make half as many widgets as the sum made by all the others, B contracts for an amount equal to one-third the sum of the others, and C can make one-quarter as many as the total of A, B and D. Company D takes an order for 325 widgets. How many widgets does each make?

News and Summaries

Defense One Year

"GOOD REASON to be pleased—dare not be satisfied," John D. Biggers of O.P.M. states in reviewing first year of defense production.

Defense production passed its first birthday on May 28. To mark the occasion, O.P.M. early last month published a booklet "Defense One Year" explaining what has been accomplished and why. This is the picture:

Machine Tools: Annual volume has risen from $220 million in 1939 to $450 million in 1940 to an estimated $750 million in 1941. About 1,000 machines are being delivered daily.

Tanks: Light tanks (13 tons) are being produced at a rate of 150 per month. On May 1st Army had 4 times as many in service as it had a year ago. This will be six-fold by the time you read this. Production of medium tanks (28 tons) was delayed purposely so that machine tools could be sent to more critical industries. Quantity production will start in the Fall.

Aircraft: Production of 1,376 military planes in April was three times that of June 1940. Nearly 10,500 military planes were produced in the first year of Defense. Monthly production, excluding civilian planes, was:

		Military and Naval
July, 1940	547	
August	586	
September	670	
October	742	
November	779	
December	900	
January, 1941	1,036	957
February	972	879
March	1,216	1,074
April	1,427	1,376

Shipbuilding: Ships are slowest of all defense production. Major combat ships on order at the end of April numbered 360; preliminary work had started on 312. Contrast this with the 43 major ships on order January 1, 1940. This table presents the picture:

	Jan. 1, 1940 On Hand	May 1, 1941 On Hand	May 1, 1941 Ordered
Battleships	15	15	17*
Aircraft Carriers	5	6	12
Cruisers	34	37	54
Destroyers	218	165	199
Submarines	87	109	78
Total	359	332	360

* Includes *North Carolina* and *Washington*, now in service.

Scout Cars: Coming out at rate of 400 per month. In July the Army will have all its requirements.

Ordnance: Powder output has risen 1,000 percent; small arms ammunition 1,200 percent. Twice as many Garand rifles are coming out monthly as in July 1940. The output of .30-cal. machine guns has trebled; that of .50-cal. machine guns has quadrupled. Gains of 40 and 35 percent are reported in field artillery and anti-aircraft artillery.

Plastic linoleum trim molding, designed to do a job formerly done by crimped aluminum strip or stainless steel molding, is here being extruded from a continuous extrusion machine at the recently expanded plant of R. D. Werner & Company. Material is Tennessee Eastman's Tenite II.

OPM Orders 50 Percent Cut in Cork Manufacture

MANUFACTURE of cork products must be reduced by 50 percent in the interests of National Defense, it was ordered last month by OPM. Reason: insufficient imports and shipping uncertainties.

While direct military requirements for cork are small, substantial quantities are used in industrial operations related to defense. Cork consumption in 1940 was divided as follows: container caps, 15 percent; gaskets and washers, 12 percent; linoleum and floor coverings, 10 percent; insulation board, 40 percent; other insulation, 20 percent; micellaneous, 3 percent.

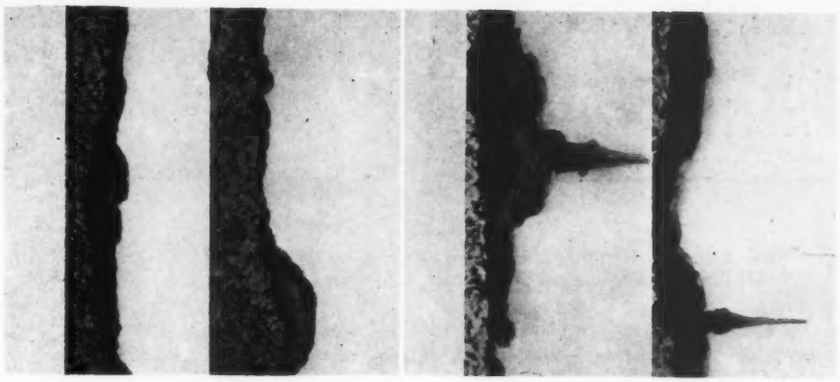
In the past, Portugal has supplied roughly 60 percent, North Africa 25 percent and Spain 15 percent of cork imports. North Africa and Spanish imports have been shut off, and the possibility of obtaining further supplies from Portugal is uncertain.

Packard Nearly Ready For Rolls Engine Production

NINE MONTHS AGO the Packard Motor Car Company signed a contract with the United States and British governments to produce 9,000 Rolls-Royce Merlin XX airplane engines. Since last September Packard has been quietly but swiftly preparing the gigantic industrial plant necessary to produce these at the rate of 800 finished motors a month.

Some conception of the size of the undertaking may be gained from the fact that the Rolls project, in full production, will employ 17,000 men. The contract called for a tooling program in excess of $28,000,000. Many of the 3,000 machines in this plan had to be designed for the job. All had to be ordered.

Ground was broken less than 9 months ago for three major new factory units totalling 500,000 sq. ft. These were completed in April. Packard found an additional 500,000 sq. ft. by consolidating automotive departments. Simultaneously, an expanding engineering department completely re-drafted the Rolls-Royce engine to accommodate American methods, machines, tools and accessories. On May 13 the first of nine pilot engines was completed. Manufacture on production basis will be in full swing within the next few weeks.



Effect of cyclic stress in accelerating corrosion is dramatically shown in these illustrations from a paper "Pitting and Its Effect on the Fatigue Limit of Steels Corroded under Various Conditions," presented June 26 by D. J. McAdam, Jr. and G. W. Geil at the Annual Meeting of A.S.T.M. Bureau of Standards research shows that corrosion pits are hemispherical at first, but change with time to saucerlike forms and spread along the surface as shown in the two magnified cross-sectional views at left. (Nickel steel; 175 days in distilled water.) Cyclic stress causes transverse extension of round or irregular pits, with development of fissures as shown at right. (Nickel steel; 149 days in distilled water; stressed to 4,000 lb. per sq. in., 1,450 cycles per min.) These effects lower fatigue limit, and are more pronounced with carbon steels.

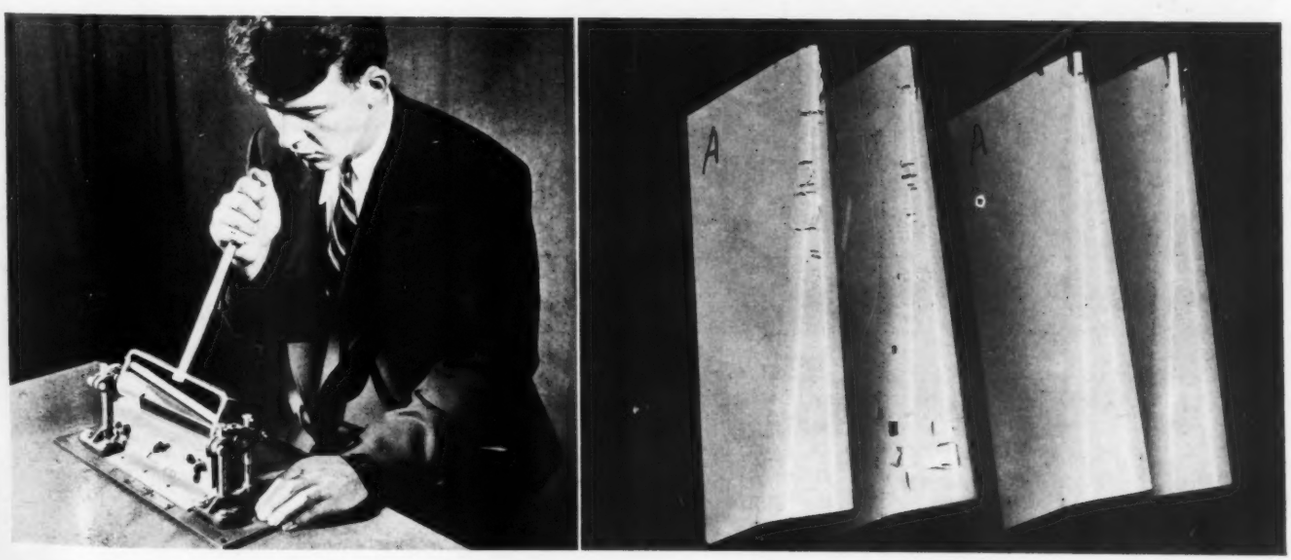
Do You Know That—

AN IN-LINE AIR-COOLED ENGINE, a 12-cylinder, supercharged inverted V-type of more than 500 hp., has been developed for Navy combat planes. Its designers believe larger in-line air-cooled engines are quite feasible. (50)

HOLLOW-BLADED STEEL propellers for military aircraft will go into production soon. They are lighter and less subject to pitting. (51)

Conical Mandrel Tests Stretchability of Finishes

AN IMPROVED TECHNIQUE for evaluating the distensibility of organic finishes, described by H. G. Arlt in *Bell Laboratories Record* for June, involves wrapping the test specimen—such as an enameled steel sheet—around a conical mandrel and computing the elongation limit of the finish from the cracks. Mandrel, shown in use at left, varies in diameter from ⅛ to 1½ in. Elongation of the outer face of the bent panel can be determined quantitatively. With finishes over 0.001 in. thick, a correction is made for added thickness. Relation between elongation and mandrel diameter varies slightly with different sheet metals. To prevent sliding action of the drawbar from marring the finish, two sheets of Kraft paper lubricated with talc are used. Coatings tested without and with these slip planes are shown at right.



ENGINEERING IN WASHINGTON

McGRAW-HILL WASHINGTON BUREAU, *PAUL WOOTON, CHIEF*

Sinking of the Bismarck is the subject of heaviest engineering thought in Washington these days, though precisely nothing official is said. One can reasonably guess that the experts are worried on two counts. One: the Nazi man-of-war possibly was superior to anything else afloat—despite the protests of Navy Secretary Knox to the contrary. Two: the damage-make ready for the kill was performed by airplanes firing torpedoes. Every day there are more editorials and more speeches in Congress. Many of them bluntly say it is silly to build $70,000,000 battleships when that same money would buy four or five hundred big bombers, any one of which might sink such a ship and a thousand men with it. No one has yet advocated stopping fleet construction.

Mosquito boat carriers are up for discussion again. Several years ago, when information was easier than it is now, it was said that taking mosquito boats to the open sea would be futile, because the water is usually too rough for them. But now, Congressman Melvin J. Maas, of Naval Affairs Committee, says he finds that no study has been made. Chairman Vinson, who is well informed on naval matters, says he is impressed by the possibilities of a torpedo boat carrier; that they could operate when the weather is unsuitable for torpedo planes.

Fifty baths an hour are provided for soldiers on the march by a new trailer unit being tested by the Army in current maneuvers. The trailer carries a boiler which provides hot bath water and steam for sterilizing soiled clothing. Four tents are used for undressing, for physical examination, salvaging used clothing, and for issuing clean garments.

Experimental station at Washington Navy Yard is being approved in Congress. There is a critical need for the Navy ordnance laboratory; it will be used particularly to experiment with new types of mines as a result of reports that the Germans have developed a mine that can be detonated by the sound of the engines of a passing ship.

Just to prove that the new Chevrolet 4x4 Army trucks with 4-wheel drive can climb, General Motors built this 60-percent grade and drove a few of them up while Army officers looked on. Similarly, the trucks made hub-cap-deep mud-holes look like duck soup. A special oil pan permits steep climbs with full lubrication of bearings and without excessive oiling of cylinder bores. Chassis and body are set 3 in. closer to ground, but 2 in. additional clearance is obtained by special transfer case design. Cab floats on rubber.

Air Corps questions the value of gliders in combat, and has told Congress so. Officers studying the matter believe that better results can be obtained with parachute troops. Suppose one tow plane and three big gliders carries 60 men. One big 60-man transport plane would cost more, but it would move the men faster. Nevertheless, Air Corps has several officers working on glider development; has authorized the training of a few glider pilots; and is purchasing 30 gliders, type not stated.

For the aircraft engine laboratory at Cleveland, operated by the National Advisory Committee for Aeronautics, President Roosevelt is asking an increase in funds from $8,400,000 to $13,300,000. The plant will not be in operation for a year or so. There is a constantly-growing need for more power, due to increasing weight of armor, armament and fuel for longer range. Airfoil design has reached a plateau, perhaps temporary, and now everything depends on concentrated power.

Biggest airplane that the Army foresees as being in regular operation in the foreseeable future would weigh 80 tons, have a 30-ft. wheel spread. Emergency landing fields are to be surfaced to take this load.

Division of Purchases (O.P.M.) will within a few weeks initiate a program of simplification of consumer goods to make more factory room for defense. Simplification will be attempted first in the radio industry, in hand tools and in hardware.

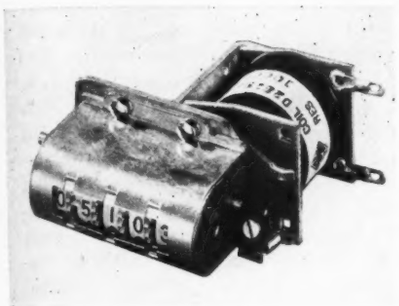
Bombs don't hurt bridges much, according to Col. Lacey Murrow, a reserve Engineer on assignment to Public Roads Administration, who has been checking up on the war in England. In most cases the bombs go harmlessly through the deck and explode below.

Tank-carrying planes have been discussed before Congressional committees. Preliminary reports are that the Germans brought half-size "light" tanks (five to seven tons) to Crete in planes. The tanks were carried in parts, designed for quick assembly. The Army believes that the great distances which it must cover in this hemisphere to reach points of possible attack, will require the use of much air-borne equipment.

New Materials and Parts

Electrical Counter

Designed and introduced as an inexpensive companion piece to the Autelco Jr. Relays, this new electrical counter is known as the Autelco Jr. Counter and is built for high-speed a.c. or d.c. operation. It is adapted to general industrial use, coin-operated



devices, etc., and is of the non-reset type. It counts up to 99,999, and then repeats. Maximum operating voltage is 240 volts, d.c., or 50-60 cycles, a.c. For a.c. operation, maximum speed is 15 counts per sec.; for d.c. operation, maximum speed is 20 counts per sec. Automatic Electric Co., 1033 W. Van Buren Ave., Chicago, Ill.

Large Gear Pump

Larger size gear type hydraulic pressure generator, known as Model G-60, has a delivery of 60 gal. per min. at 1,000 lb. per sq.in. line pressure. The pump is a constant delivery type. Close tolerances are maintained between working parts so that pump output efficiency is high. Precision spur gears of narrow width and large pitch diameter are used, reducing both the hydraulic load on the gears and the distance between the gear shaft bearings so that shaft deflection is minimized. Gear shafts are mounted on precision Timken tapered roller bearings. Internal adjustment permits compensation for bearing wear. The Hydro-Power Model G Pump is recommended for operation at 1,000 lb. per sq.in., where peak pressures are momomentary; or for operating up to 500 lb. per sq.in., where peak pressures are maintained. Hydro-Power Systems, Inc., Mt. Gilead, Ohio.

Carbonyl Iron Powder

Carbonyl iron powder, which differs from other commercial iron powders in that it has an extremely small spherical particle size ranging from $1\frac{1}{2}$ to 5 microns, is now being produced in the United States. Principle uses for this fine powder at present are in electrical devices, such as iron cores, choke coils, etc., where the small particles are desired to reduce hysteresis losses. Carbonyl iron powders are also especially suitable for certain types of sintered alloys in the fast-growing field of powder metallurgy. Grades of carbonyl iron powder will soon be developed specifically for powder metallurgy. The material is being produced at the Grasselli, N. J. plant of the General Aniline Works. Sales agent is Advance Solvents & Chemical Corp., 245 Fifth Ave., New York, N. Y.

Coil Winding Gage

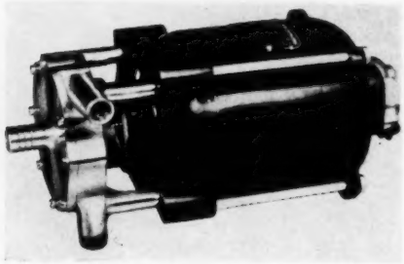
Speeds as high as 9,000 turns per min. can be counted by the new Clipper high speed coil winding counter, designed for direct connection to the motor shaft or for operation through a flexible shaft. Reset to zero is accomplished with a single motion. Unique pointer design gives instant visual check of reset. Turns taken off the coil in case of over-run which may occur in high-speed winding are deducted by the Clipper. Large, legible figures read to 10,000 turns. Pointers have specially designed friction hubs which have large bearing area for dependability and minimum wear. Main bearing is Oilite, and gears are hobbed throughout for precision. The gage can easily be aligned by shifting the adjustable base. Production Instrument Co., 702-10 W. Jackson Blvd., Chicago, Ill.

Tubular Lamp

This new tubular lamp fits into a T6$\frac{1}{2}$ tubular bulb that is only $\frac{3}{4}$-1 in. in diameter and 5 in. long. It has its own built-in reflector in the form of a pure silver lining hermetically sealed inside the bulb where it cannot tarnish or lose in operating efficiency. Brilliance is increased by a special filament, coiled once and then recoiled over its entire length to provide a more concentrated and economical light. Three metal supports anchor the filament in place and protect it against vibration hazards. Available in 15, 25, and 40-watt sizes. Average burning life is 1,000 hr. Wabash Appliance Corp., Brooklyn, N. Y.

Explosion-Proof Pump

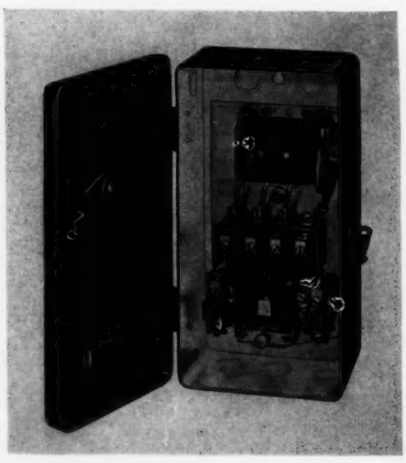
Midget size explosion-proof pump, designated as Model D, can be used in all industrial, pilot plant, laboratory and experimental applications where an explosion-proof unit is necessary. Maximum pressure is 16 lb. per sq.in.; maximum capacity is 5.7 gal.



per min. Motor is 1/12 hp., 3,450 r.p.m., for use on single-phase 110 or 220-volt, 60-cycle, a.c. Motor, armature and pump impeller are mounted on a single shaft. Available in stainless steel, Monel metal, chromium plated bronze, brass, cast iron, and other alloys. Eastern Engineering Co., 45 Fox St., New Haven, Conn.

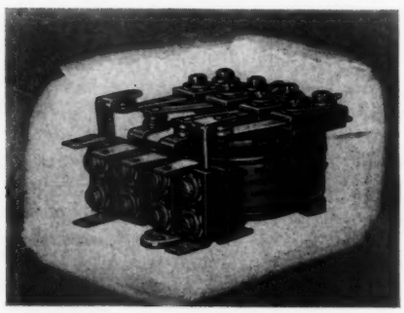
Combination Starters

By combining a magnetic switch with a hand-disconnect switch in the same inclosure, these starters save wiring, insure greater safety to the operator, and result in compact installation and improved appearance. The disconnect switch lever is located on the front instead of on the side of the cabinet. Three holes for padlocks in the disconnect switch lever permit the switch to be locked when the lever is off. One, two or three padlocks can be used. Hence, electrician, mechanic and millwright may each insert padlocks, and the switch cannot be closed until all three padlocks are removed. The cover can be padlocked independently of the operating lever. Both disconnect switch and solenoid switch have silver alloy contacts. Available in four sizes in a variety of inclosures with or without fuse clips. Ratings range from 2 hp., 220-440-550 volts for the Size 0 starter, to 30 hp., 220 volts, and 50 hp., 440-550 volts for the Size 3 starter. All sizes have interrupting capacity at least ten times the maximum horsepower rating. Allen-Bradley Co., 1311 S. First., Milwaukee, Wis.



Four-Pole Relay

New four-pole industrial relay is compact, small in size, and positive and reliable in action. Designated as Series 980, these relays are only $2\frac{1}{4}$ in. wide, $1\frac{1}{2}$ in. high, and $2\frac{7}{8}$ in. deep. Capacity is 10 amp. at 110 volts. Available with $\frac{1}{8}$-in., $\frac{3}{16}$-in., or $\frac{1}{4}$-in. contacts; four-pole, single-throw, either normally



open or normally closed; four-pole, double-throw; or four-pole, two make and two break as illustrated. Advance Electric Co., 1260 W. 2nd St., Los Angeles, Calif.

Black Finish for Copper

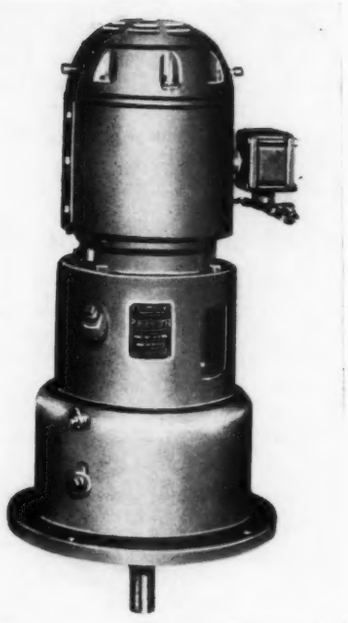
A new Electro-Jetal Process, which can blacken any metal that can be copper-plated, gives a black rustproof finish on copper by anodic oxidation. After preplating with copper, products are immersed in a special electrolytic oxidizing bath for 2 to 5 min. The resulting velvety black surface of Electro-Jetal is an excellent absorptive base for an after-treatment of oil, wax or lacquer which gives a non-porous, rust-proof finish equivalent to ordinary nickel plate. The new Electro-Jetal bath can be operated at any temperature below the boiling point of water, using ordinary steel containers heated by steam coil. Work can be oxidized on racks, in bulk or baskets. Cost of chemical, exclusive of the copper plate, is approximately 25 cents per 1,000 sq.ft. of surface. Alrose Chemical Co., Providence, R. I.

Mycalex Now Injection Molded

Mycalex, a plastic material composed of ground mica and lead-borate glass, can now be injection molded. The material has been available for several years in compression-molded plates and bars which could be machined to specified shape. In general, Mycalex has better electrical characteristics than porcelain, and is stronger except under compression. It is not as refractory as porcelain or mica, but is superior in this respect to ordinary molded compounds. Its use is particularly advantageous where requirements demand high dielectric strength and insulation resistance; low losses at high frequencies; high mechanical strength; arc resistance; heat resistance; and a compact construction with metal inserts securely molded in place. In addition, Mycalex has high chemical and dimensional stability, and has low coefficient of thermal expansion. Applications of injection-molded Mycalex are tube bases, switch insulation, radio structural parts, arc chutes, relay insulators, and as inserts in die-castings and organic plastics. General Electric Co., Pittsfield, Mass.

Tachometer

To eliminate the undesirable features of the conventional d.c. tachometer, a new a.c. tachometer uses no brushes or commutator in the non-sparking generator unit. The a.c. voltage generated is rectified and indicated in terms of rotational or linear speeds. In the illustration, the indicating instrument to the left can be calibrated in r.p.m., ft. per min., gal. per min., or other units depending on the application. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.



Agitator Drive

Because this new agitator drive, designated "Portereducer," utilizes the planetary system of gearing, the unit has several advantages over other reduction gears now in use in agitators. Many more teeth are in action than in conventional systems; this fact means that operation is smoother, greater reduction can be accomplished in a given space, and tooth load is at a minimum for any given torsional effort. Quiet, smooth operation is effected by the use of helical gears. Heat-treated alloy steel gears and shafts, and Timken anti-friction bearings insure maximum strength and durability. Designed to use standard NEMA frame motors. H. K. Porter Co., Inc., 4969 Harrison St., Pittsburgh, Pa.

High-Speed Belt

Endless belt for high-speed precision work, known as the Gilmer-Hevaloid Belt, has such pliability and lightness in weight that it is suitable for operation at speeds up to 9,000 ft. per min. over pulleys of small diameters. A unique process of impregnating the cotton pulling element with latex results in special qualities of elasticity, strength and durability. Made without lap, seam or splice, the belt operates free from vibration. Non-slip surface with high coefficient of friction permits lighter tension, decreased bearing load, and maintains a higher and more uniform driven speed on drives such as routing machines, winders, grinders and similar applications. L. H. Gilmer Co., Tacony, Philadelphia, Pa.

Spark-Proof Wheel

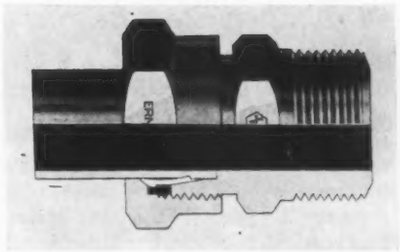
To prevent the development of sparks caused by either striking an abrasive or the building up of a static electric potential in the truck, these non-metallic truck wheels of laminated plastic material have an electrical conductor embedded in the plastic surrounding the hub and extending to the rim of the wheel. This conductor is a soft copper wire or cable, and prevents a potential capable of producing a spark from being built up on the truck or its load. Divine Bros., Utica, N. Y.

Dry Developer Paper

This improved sensitized paper for white print dry developer or ammonia vapor machines has a 50 percent rag content as compared with the sulphite stock used in existing papers. It has two "speeds" in sensitivity, regular and fast. It is available in two colors, deep royal blue, and "Post" red. The new sensitizing medium is claimed to print out to a cleaner, whiter background and at the same time leave all lines in deeply colored contrast. Special emphasis is placed upon the crisp detail of fine lines. Samples of "Vapopaper" are available free to users of ammonia vapor machines who are willing to submit a brief report on its performance in return. Frederick Post Co., Box 803, Chicago, Ill.

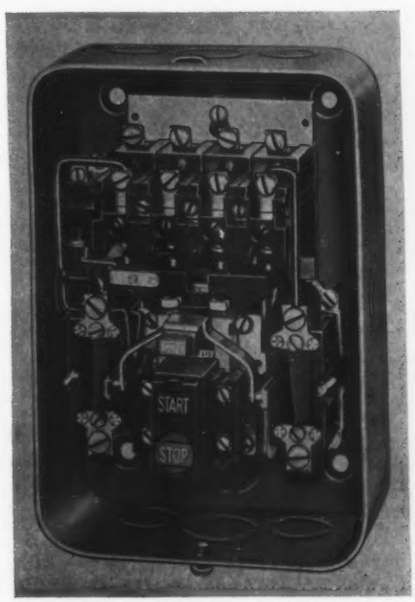
Tube Fitting

On this new fitting, known as the Ermeto safety fitting, the cutting edge of a hardened ring shears a groove into the outer surface of the tube. The resulting leak-proof joint cannot be pulled apart and holds beyond the burst strength of the tube itself. No flaring, threading, soldering or welding is necessary. Connections made can be easily taken apart and remade without affecting the tightness of the joint. Ermeto fittings made from steel are ideal for high-pressure applications in aviation, machine-tool, petroleum, oil-refining, refrigeration, automotive, railroad, and are available as nipples, connectors, unions, elbows, tees and sleeves for tube diameters ranging from $\frac{1}{8}$ in. to $1\frac{1}{2}$ in. outside diameter. The Weatherhead Co., Cleveland, Ohio.



Magnetic Starters

Separate Bakelite units for each pole of these new magnetic solenoid starters and contactors, sizes 0 and 1, confine the arc and exclude dust. All connections are made from the front, and coils with clearly visible ratings are easily changed. Separate electrical interlock switch, inclosed in Bakelite, is supplied normally open or normally closed. Reset button is independent of the cover. Positive quick make and break switching mechanism in overload relay is insulated from the bimetal and heater. Overload relays are regularly supplied for manual reset, but can be changed for automatic reset if desired. Suitable for control of motors up to $7\frac{1}{2}$ hp., single or polyphase, 110-550 volts a.c. The Arrow-Hart & Hegeman Electric Co., 103 Hawthorn St., Hartford, Conn.



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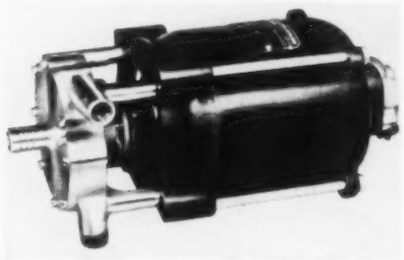

per min. Motor is 1/12 hp., 3,450 r.p.m., for use on single-phase 110 or 220-volt, 60-cycle, a.c. Motor, armature and pump impeller are mounted on a single shaft. Available in stainless steel, Monel metal, chromium plated bronze, brass, cast iron, and other alloys. Eastern Engineering Co., 45 Fox St., New Haven, Conn.

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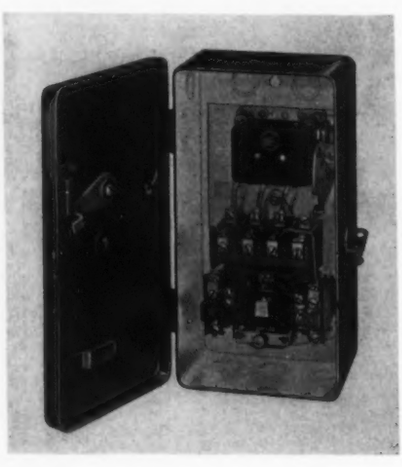
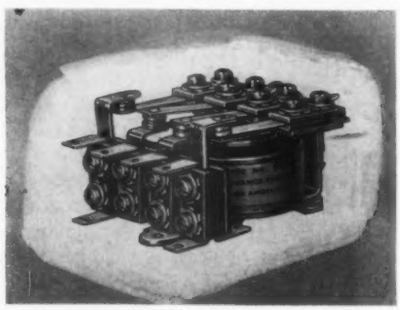


Four-Pole Relay

New four-pole industrial relay is compact, small in size, and positive and reliable in action. Designated as Series 980, these relays are only $2\frac{1}{4}$ in. wide, $1\frac{1}{2}$ in. high, and $2\frac{7}{8}$ in. deep. Capacity is 10 amp. at 110 volts. Available with $\frac{1}{8}$-in., $\frac{3}{16}$-in., or $\frac{1}{4}$-in. contacts; four-pole, single-throw, either normally



open or normally closed; four-pole, double-throw; or four-pole, two make and two break as illustrated. Advance Electric Co., 1260 W. 2nd St., Los Angeles, Calif.

Black Finish for Copper

A new Electro-Jetal Process, which can blacken any metal that can be copper-plated, gives a black rustproof finish on copper by anodic oxidation. After preplating with copper, products are immersed in a special electrolytic oxidizing bath for 2 to 5 min. The resulting velvety black surface of Electro-Jetal is an excellent absorptive base for an after-treatment of oil, wax or lacquer which gives a non-porous, rust-proof finish equivalent to ordinary nickel plate. The new Electro-Jetal bath can be operated at any temperature below the boiling point of water, using ordinary steel containers heated by steam coil. Work can be oxidized on racks, in bulk or baskets. Cost of chemical, exclusive of the copper plate, is approximately 25 cents per 1,000 sq.ft. of surface. Alrose Chemical Co., Providence, R. I.

Mycalex Now Injection Molded

Mycalex, a plastic material composed of ground mica and lead-borate glass, can now be injection molded. The material has been available for several years in compression-molded plates and bars which could be machined to specified shape. In general, Mycalex has better electrical characteristics than porcelain, and is stronger except under compression. It is not as refractory as porcelain or mica, but is superior in this respect to ordinary molded compounds. Its use is particularly advantageous where requirements demand high dielectric strength and insulation resistance; low losses at high frequencies; high mechanical strength; arc resistance; heat resistance; and a compact construction with metal inserts securely molded in place. In addition, Mycalex has high chemical and dimensional stability, and has low coefficient of thermal expansion. Applications of injection-molded Mycalex are tube bases, switch insulation, radio structural parts, arc chutes, relay insulators, and as inserts in die-castings and organic plastics. General Electric Co., Pittsfield, Mass.

Tachometer

To eliminate the undesirable features of the conventional d.c. tachometer, a new a.c. tachometer uses no brushes or commutator in the non-sparking generator unit. The a.c. voltage generated is rectified and indicated in terms of rotational or linear speeds. In the illustration, the indicating instrument to the left can be calibrated in r.p.m., ft. per min., gal. per min., or other units depending on the application. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Agitator Drive

Because this new agitator drive, designated "Portereducer," utilizes the planetary system of gearing, the unit has several advantages over other reduction gears now in use in agitators. Many more teeth are in action than in conventional systems; this fact means that operation is smoother, greater reduction can be accomplished in a given space, and tooth load is at a minimum for any given torsional effort. Quiet, smooth operation is effected by the use of helical gears. Heat-treated alloy steel gears and shafts, and Timken anti-friction bearings insure maximum strength and durability. Designed to use standard NEMA frame motors. H. K. Porter Co., Inc., 4969 Harrison St., Pittsburgh, Pa.

High-Speed Belt

Endless belt for high-speed precision work, known as the Gilmer-Hevaloid Belt, has such pliability and lightness in weight that it is suitable for operation at speeds up to 9,000 ft. per min. over pulleys of small diameters. A unique process of impregnating the cotton pulling element with latex results in special qualities of elasticity, strength and durability. Made without lap, seam or splice, the belt operates free from vibration. Non-slip surface with high coefficient of friction permits lighter tension, decreased bearing load, and maintains a higher and more uniform driven speed on drives such as routing machines, winders, grinders and similar applications. L. H. Gilmer Co., Tacony, Philadelphia, Pa.

Spark-Proof Wheel

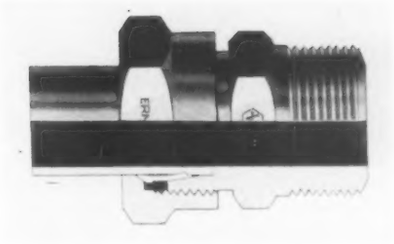
To prevent the development of sparks caused by either striking an abrasive or the building up of a static electric potential in the truck, these non-metallic truck wheels of laminated plastic material have an electrical conductor embedded in the plastic surrounding the hub and extending to the rim of the wheel. This conductor is a soft copper wire or cable, and prevents a potential capable of producing a spark from being built up on the truck or its load. Divine Bros., Utica, N. Y.

Dry Developer Paper

This improved sensitized paper for white print dry developer or ammonia vapor machines has a 50 percent rag content as compared with the sulphite stock used in existing papers. It has two "speeds" in sensitivity, regular and fast. It is available in two colors, deep royal blue, and "Post" red. The new sensitizing medium is claimed to print out to a cleaner, whiter background and at the same time leave all lines in deeply colored contrast. Special emphasis is placed upon the crisp detail of fine lines. Samples of "Vapopaper" are available free to users of ammonia vapor machines who are willing to submit a brief report on its performance in return. Frederick Post Co., Box 803, Chicago, Ill.

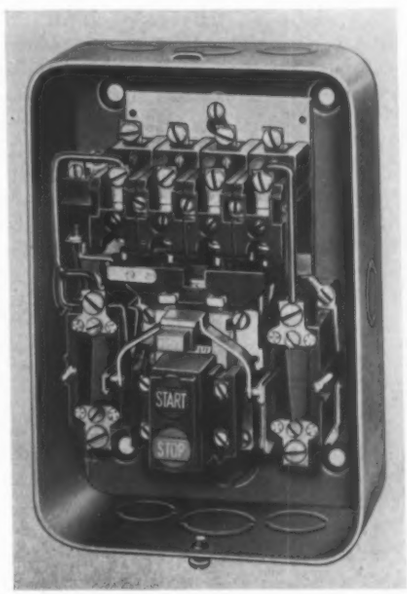
Tube Fitting

On this new fitting, known as the Ermeto safety fitting, the cutting edge of a hardened ring shears a groove into the outer surface of the tube. The resulting leak-proof joint cannot be pulled apart and holds beyond the burst strength of the tube itself. No flaring, threading, soldering or welding is necessary. Connections made can be easily taken apart and remade without affecting the tightness of the joint. Ermeto fittings made from steel are ideal for high-pressure applications in aviation, machine-tool, petroleum, oil-refining, refrigeration, automotive, railroad, and are available as nipples, connectors, unions, elbows, tees and sleeves for tube diameters ranging from $\frac{1}{8}$ in. to $1\frac{1}{2}$ in. outside diameter. The Weatherhead Co., Cleveland, Ohio.



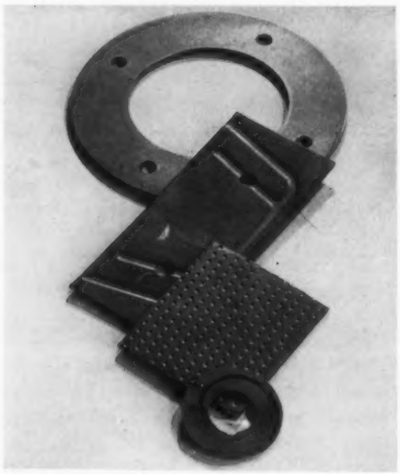
Magnetic Starters

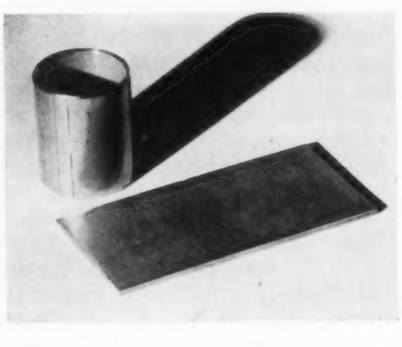
Separate Bakelite units for each pole of these new magnetic solenoid starters and contactors, sizes 0 and 1, confine the arc and exclude dust. All connections are made from the front, and coils with clearly visible ratings are easily changed. Separate electrical interlock switch, inclosed in Bakelite, is supplied normally open or normally closed. Reset button is independent of the cover. Positive quick make and break switching mechanism in overload relay is insulated from the bimetal and heater. Overload relays are regularly supplied for manual reset, but can be changed for automatic reset if desired. Suitable for control of motors up to $7\frac{1}{2}$ hp., single or polyphase, 110-550 volts a.c. The Arrow-Hart & Hegeman Electric Co., 103 Hawthorn St., Hartford, Conn.



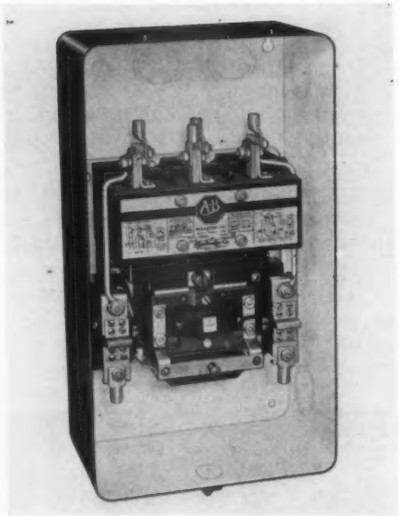
Bronze on Steel Bearings

Pre-cast bearing Bronze on Steel is essentially a thin-wall, laminated type of bearing that combines bearing qualities of a high-grade bronze alloy with the strength of steel. By casting a bronze alloy (S.A.E. 64, 80 percent copper, 10 percent tin, 10 percent lead) in solid bronze bars, the metals are chemically united to form a definite





copper-tin eutetic, with the lead trapped in the interstices. Next, the center of each casting is removed by drilling; the borings thus obtained are reduced to a powder, treated in a hydrogen furnace to remove all oxides, and then firmly bonded to strip steel. The process of manufacturing bearings from Bronze on Steel, in strip form, is the same as for any other type of sheet metal bearing. Advantages claimed are higher Brinell hardness, greater resistance to pounding and to shock, and a comparatively low coefficient of friction. The Bronze on Steel bearings can be formed to practically any shape required, and can be purchased already formed or in strip rolls up to 400 ft. in length. Pre-cast bearing Bronze on Steel is also available as a graphited bearing. For special bearing surfaces, the bronze can be bonded to both surfaces. Johnson Bronze Co., New Castle, Pa.



Large Solenoid Starter

To meet the demand for a larger starter with a solenoid switch structure, this new unit has a maximum horsepower rating of 50 hp., 220 volts, and 100 hp., 440-550-600 volts. Developed to replace the older Bulletin 710, the new Bulletin 709 solenoid starter has all the features of the smaller starter. By employing the solenoid design, the size of the starter has been greatly reduced. At the same time a generous amount of wiring space is provided, and the inclosure is attractively styled. Arc-interrupting capacity is high. The switch has only one moving part and is free from complicated mechanism. Wiring is made easy by plainly marked, accessible terminals, and by the white enameled interior which eliminates dark shadows. The starter is mounted on a self-insulated metal baseplate which can be mounted on any metal surface without extra insulation. Allen-Bradley Co., 1311 S. First St., Milwaukee, Wis.

Bright Copper Plate

Due to the shortage of nickel, many concerns are thinking seriously of going over to heavy copper deposits, followed by comparatively light nickel deposits. For that reason, bright heavy copper deposits are advantageous. Basic ingredients of a bright plating process recently announced are copper sulphate, diethylene triamine and ammonium sulphate. Current efficiency at both anode and cathode is practically 100 percent, and the throwing power compares favorably with a cyanide copper solution. Average current density is about 40 amp. per sq.ft. for optimum brightness. Operating temperature is 140 deg. F. Equipment is rubber lined. Anodes are preferably of electrolytic copper, although cast copper anodes can be used. A cyanide copper flash of 2 or 3 min. is required before plating on zinc or steel. Hanson-Van Winkle-Munning Co., Matawan, N. J.

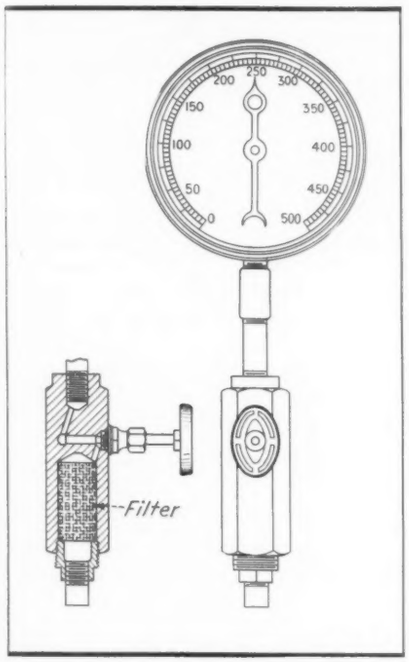
Centrifugal Coolant Pumps

Centrifugal pump, which delivers cutting oil or compound the moment the pump begins to operate, has no metal-to-metal contact. This construction permits the handling of liquids charged with filings, small chips, and abrasive impurities as large as 0.035

in. in dia. The pump, the $\frac{1}{4}$-hp. explosion-resisting motor, and the motor switch are all assembled as an integral unit, compact and simple. The motor, which has a notably low starting torque, has no brushes or commutator. Only half the usual number of bearings are required, and the lower bearing is grease-packed. Between motor and pump is a positive mechanical seal. Capacity is 13 to 15 gal. per min., full flow, $\frac{3}{4}$-in. discharge. Gilbert & Barker Mfg. Co., Springfield, Mass.

Fiber Glass Adhesive Tape

Adhesive tape of fiber glass, with a pressure-sensitive coating, is now available. The new product will have a number of uses in the electrical industry and for insulating other than electrically. The tape is manufactured from common woven glass textile in rolls to a full width of 40 in. It can then be cut into any desired widths, exactly as paper-backed and cloth-backed tapes are cut. In use by the consumer it is applied and cut just as any other adhesive tape. Industrial Tape Corp., New Brunswick, N. J.



Micro-Action Valve

Effective as protection to any control valve, and for use with sensitive control instruments subjected to pulsating flow, this micro-action valve consists of a solid brass body in which a filter is inserted for protection from foreign matter. The valve has an extremely slight taper so that very sensitive control of the shutoff is effected. It can be installed on the pressure line to the diaphragm of a pump governor, for instance, to eliminate pulsation. The valve will handle steam, fuel oil, gas, water or other liquids, with simple adjustment for each viscosity. J. A. Campbell Co., 645 E. Wardlow Rd., Long Beach, Calif.

Plastic Coating for Castings

Porous castings which do not quite hold specified pressures, due to factors beyond the control of the manufacturer, may be made entirely satisfactory by impregnating them with a Durez phenolic resin designated 7347-A. The impregnation is accomplished by forcing the resin into the pores of the casting under air pressure; pressures between 45 and 100 lb. per sq.in. are recommended. Larger castings can be sealed and the resin pumped directly into the casting. Baking is necessary to thoroughly set or polymerize the resin. Small castings are baked in an oven for several hours at 250 to 275 deg. F., or preferably in a pressure tank by applying steam. Baking under pressure produces a cleaner, smoother surface. Durez Plastics & Chemicals, Inc., North Tonawanda, N. Y.

Manufacturers' Publications

Materials

ADHESIVE TAPES—Industrial Tape Corp., New Brunswick, N. J. Sample folder, 4 pages, 3¾ x 8½ in. Contains sample strips of nine different types of industrial adhesive tapes.

PLASTICS—General Electric Co., Pittsfield, Mass. "The Change to Plastics" is the title of this new attractive folder and it gives twelve case histories where plastics are used to replace other materials.

STEEL—Joseph T. Ryerson & Son, Inc., 16th & Rockwell Sts., Chicago, Ill. Catalog 1941, 268 pages, 4¾ x 5 in. New products, new analyses and new sizes plus an increased number of helpful charts and tables have been added to this edition of Ryerson's stock list.

Mechanical Parts

AIRFLEX COUPLINGS—Falk Corp., 3001 W. Canal St., Milwaukee, Wis. Bulletin 8100, 20 pages, 8½ x 11 in. Contains typical installation views, discussion of principles, and dimension drawings and tables covering each type of Airflex couplings.

BEARINGS—The Timken Roller Bearing Co., Canton, Ohio. "The Vital Importance of Timken Bearings in National Defense," 32 pages, 9 x 12 in. Illustrates and describes the Timken efforts in behalf of the National Defense Program.

EXPANSION BOLTS—Rawlplug Co., Inc., 98 Lafayette St., New York, N. Y. Catalog 41, 38 pages, 3½ x 6¼ in. Valuable data, charts and tables on expansion anchors, with every type of anchor made by Rawlplug listed, is included.

FILTERS — Staynew Filter Corp., 25 Leighton Ave., Rochester, N. Y. Catalog, 44 pages, 8½ x 11 in. Illustrates and describes Staynew and Protectomotor filters for compressed-air, gases, liquids, engine and compressor intake, and for building ventilation. Detailed engineering data is included.

LOCK NUTS—Security Metal Products, Inc., 345 East Kalamazoo Ave., Kalamazoo, Mich. One page, 8½x11 in. Brief description of the Security vibration proof lock nut.

OILED-AIR LUBRICATION—C. A. Norgren Co., Inc., Denver, Colo. Catalog 400, 24 pages, 8½ x 11 in. Oiled-air lubrication for high-speed spindle bearings and for solving other difficult lubricating problems is described in this booklet. Lubro-Control units for the control, cleaning and lubrication of air are listed.

POROUS-BRONZE BEARINGS—Bound Brook Oil-Less Bearing Co., Bound Brook, N. J. 1941 Die List, 12 pages, 8½ x 11 in. Gives complete listing of Compo oil-retaining porous bronze bearings. Length sizes are now specified "any length up to —".

SOCKET HEAD SCREWS — Holo-Krome Screw Corp., Hartford, Conn. Pamphlet, 12 pages, 8½ x 11 in. Illustrates, tabulates and gives formulas for dimensions for socket set screws and socket head cap screws of the hexagonal type.

SPRING WASHERS—National Lock Washer Co., Newark, N. J. Two bulletins, 12 pages, 8 x 10 in. One of these bulletins covers Kantlink steel spring washers, the other covers non-ferrous spring washers. Particularly valuable is a table of recommended spring washer sizes for a given bolt or screw application.

V-BELTS—Manheim Mfg. & Belting Co., Manheim, Pa. "Veelos Picturegraph," 24 pages, 9½ x 10¾ in. This interesting primer describes by means of pictures the principal advantages and applications of Veelos adjustable belts.

Electrical Parts

ADJUSTABLE SPEED DRIVE—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. Bulletin DD-4063, 4 pages, 8½ x 11 in. Gives design details of adjustable speed drives between 1 and 15 hp., including motor generator, d.c. drive motor and rheostat. Typical curves show variation in percentage torque with speed.

ELECTRICAL EQUIPMENT — Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. Catalog 30-000, 64 pages, 8½ x 11 in. Revised edition of the popular "Quick Selector" catalog of electrical equipment for any motor, lighting or feeder circuit.

INSULATING VARNISHES—Irvington Varnish & Insulator Co., Irvington, N. J. Manual, 34 pages, 8½ x 11 in. Designed to assist in the proper selection and application of insulating varnishes, this booklet describes 31 Harvel and Irvington insulating varnishes, paints and enamels.

PLUGGING CONTROL—General Electric Co., Schenectady, N. Y. Bulletin GEA-3571, 4 pages, 8 x 10½ in. Illustrates and describes G-E plugging control, and shows diagrammatically eight different ways to apply the plugging switch.

SPEED VARIATOR—General Electric Co., Schenectady, N. Y. GEA-3517, 4 pages, 8x10½ in. Describes the compact unit, composed of standard parts, which is an adjustable speed drive operating from a.c. to drive a d.c. motor.

Books and Bulletins

Prevention of the Failure Of Metals under Repeated Stress

BATTELLE MEMORIAL INSTITUTE—*273 pages, 171 illustrations, 6¼x9¼ in. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y. Price $2.75.*

Fatigue failures, such as have been illustrated during the past months in PRODUCT ENGINEERING'S "Causes & Cures," can be attributed in large part to lack of knowledge or appreciation of engineering principles among designers, machine shop superintendents and workmen. Most of the engineering principles involved in precautions against fatigue failures were already on the record but were so widely scattered that the National Research Council, at the investigation of the Bureau of Aeronautics, arranged a conference of leading authorities on the subject and commissioned Battelle Memorial Institute to prepare this compilation.

This book is without doubt the most complete and authoritative up-to-date work on the subject of fatigue failures. After covering the general nature of fatigue failures, the book discusses stress concentration caused by fillets, keyways, oil holes, corrosion, tool marks, work-hardened surfaces, notches, internal stresses. Stress reversals, peak stresses and their effects are fully explained.

Many chapters in the Appendix present experimental test data showing, as exactly as have so far been determined, the factors influencing fatigue stresses. The book uses many illustrations of failures as examples. A 23-page bibliography completes the compilation.

Practical Solution Of Torsional Vibration Problems

W. KER WILSON—*Second Edition, Vol. I. 731 pages, 5½x9½ in. Blue clothboard covers. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y. Price $8.*

In addition to the inclusion of new practical design data and a more comprehensive treatment of vibration problems peculiar to high-speed engines, the text and illustrations in this second edition bring up-to-date the subject matter of the first edition, thus presenting a modern text covering problems encountered in the marine, electrical, aeronautical and automotive fields of design.

Among the important changes and revisions in Vol. I are a fuller treatment of new material on such subjects as flexible couplings, choice of crank sequence and firing order of single- and multi-row radial engines and V-type engines, and geared engines supported on flexible mountings. Also there is included a simple practical treatment of air-screw blade vibration and its influence on the vibration characteristics of aircraft power plants. Vol. II will be published shortly.

Metallurgy Of Deep Drawing and Pressing

J. DUDLEY JEVONS—*699 pages, 6x9¾ in. Green clothboard covers Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y. Price $10.*

This book is a valuable source of information for all designers who are intimately associated with production procedure and the tools used in making deep drawn sheet metal products.

After describing in detail the technology employed in Great Britain to produce brass and steel sheet, the author discusses the difficulties experienced in the press shop which are attributable to defects in the sheet as supplied to the press, and also processing difficulties attributable to the treatment accorded the metal under the press. The techniques of deep drawing aluminum and its alloys, magnesium alloys, copper, nickel and nickel alloys, zinc, stainless and alloy steels are appropriately covered in a separate chapter. There are also chapters on presses, tools, lubricants, testing of sheet metal, behavior properties, specifications and new applications.

Engineers' Manual Of Statistical Methods

LESLIE E. SIMON—*231 pages, 6¾x10 in. Green buckram covers. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y. Price $2.75.*

Statistics is one of a number of convenient tools for accomplishing a professional end. To the design engineer, this end is the establishment of design specifications which can be maintained in the shop. To achieve this end he must understand statistical methods of inspection and production control.

There have been books published before on the subject, but Mr. Simon thought most of these books were too heavy for the average practical man whose interest is centered in his industrial or engineering work. Hence this book, which summarizes the probability, statistics and logic entering into inspection and process control methods as briefly as is compatible with clarity.

The principles set forth by Mr. Simon are predicated on research conducted at the Ballistics Research Laboratory and on experience gained in production for the Government in U. S. Arsenals.

Tables of Sine, Cosine And Exponential Integrals

Vol. I, 470 pages, 8½x11 in. Vol. II, 260 pages, 8½x11 in. Tan buckram covers. Published by National Bureau of Standards, U. S. Dept. of Commerce, Washington, D. C. Price $2 per volume.

The integral functions tabulated in these volumes are encountered in many fields of pure and applied mathematics, including problems in electrical engineering, chemistry and physics. Supplementing the tables are many references showing the variety of applications of these functions.

These tables represent another step in the work being done by the Works Progress Administration for New York in preparing mathematical tables.

• • •

Open Hearth Alloy Steels And Electric Furnace Steels

Steel Products Manual, Sec. 10. 39 pages. 6 x 9 in. Published by American Iron and Steel Institute, 350 Fifth Ave., New York, N. Y. Price 25 cents.

This new section of the Steel Products Manual gives general description and technical data covering basic open hearth alloy steels and electric furnace steels in blooms, billets, slabs, bars and hot-rolled strip. Standard chemical compositions, methods for testing and manufacturing practices are well covered.

Drafting Standards Accepted and Proposed

30 pages, 8½x11 in. Published by Chas. M. Higgins & Co., Inc., 271 Ninth St., Brooklyn, N. Y. Price in quantities 25 cents; single copies to engineers free.

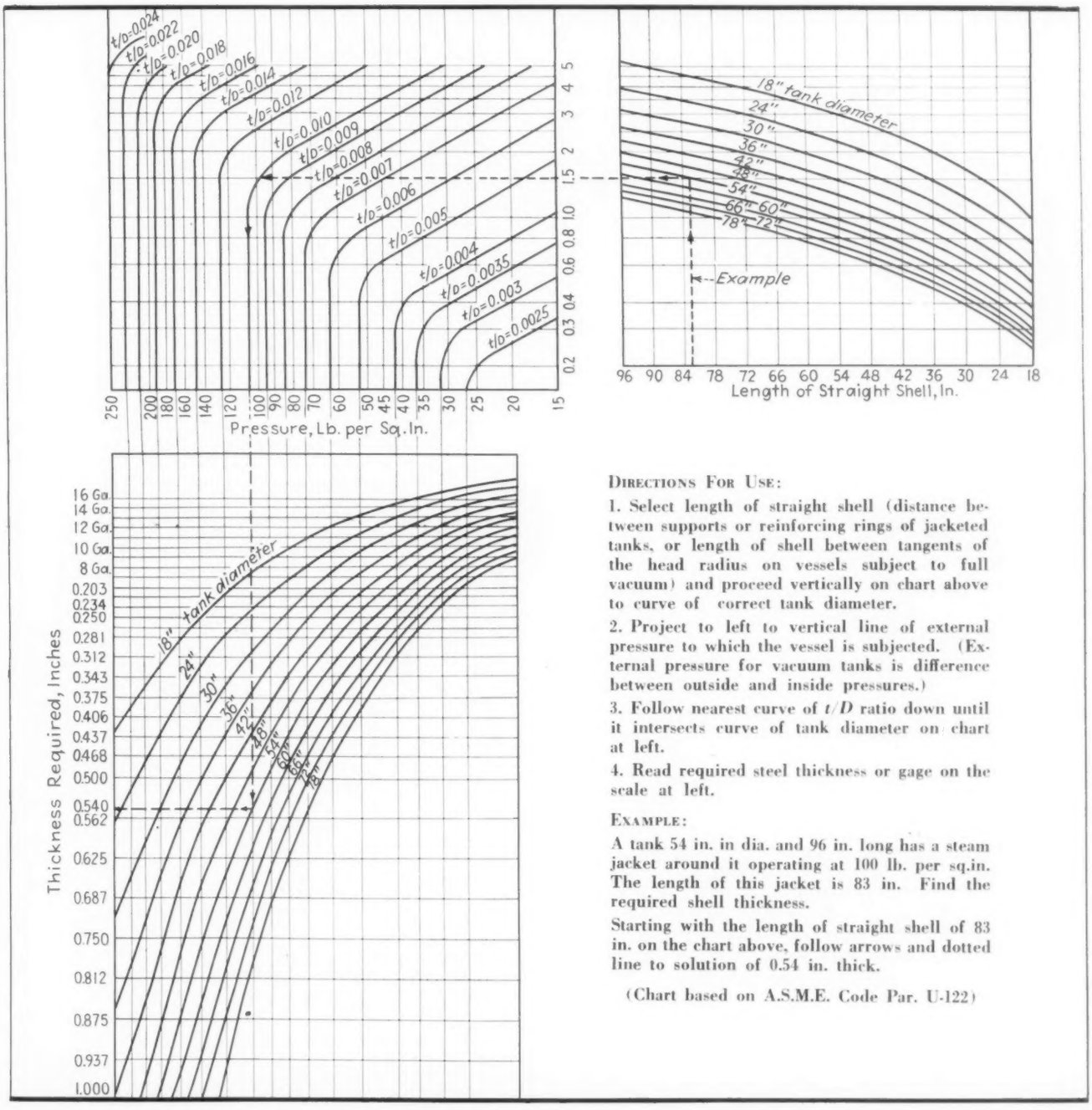
This new brochure holds between its covers the complete drafting standards of the American Society of Mechanical Engineers and the American Welding Society, as well as one page of proposed standards not yet accepted by the American Standards Association and not to be found elsewhere in printed form.

UNFIRED PRESSURE VESSELS

Shell and Dished Head Thickness Charts

EDWARD L. MAGUIRE

SHELL THICKNESS—EXTERNAL PRESSURE



DIRECTIONS FOR USE:

1. Select length of straight shell (distance between supports or reinforcing rings of jacketed tanks, or length of shell between tangents of the head radius on vessels subject to full vacuum) and proceed vertically on chart above to curve of correct tank diameter.

2. Project to left to vertical line of external pressure to which the vessel is subjected. (External pressure for vacuum tanks is difference between outside and inside pressures.)

3. Follow nearest curve of t/D ratio down until it intersects curve of tank diameter on chart at left.

4. Read required steel thickness or gage on the scale at left.

EXAMPLE:

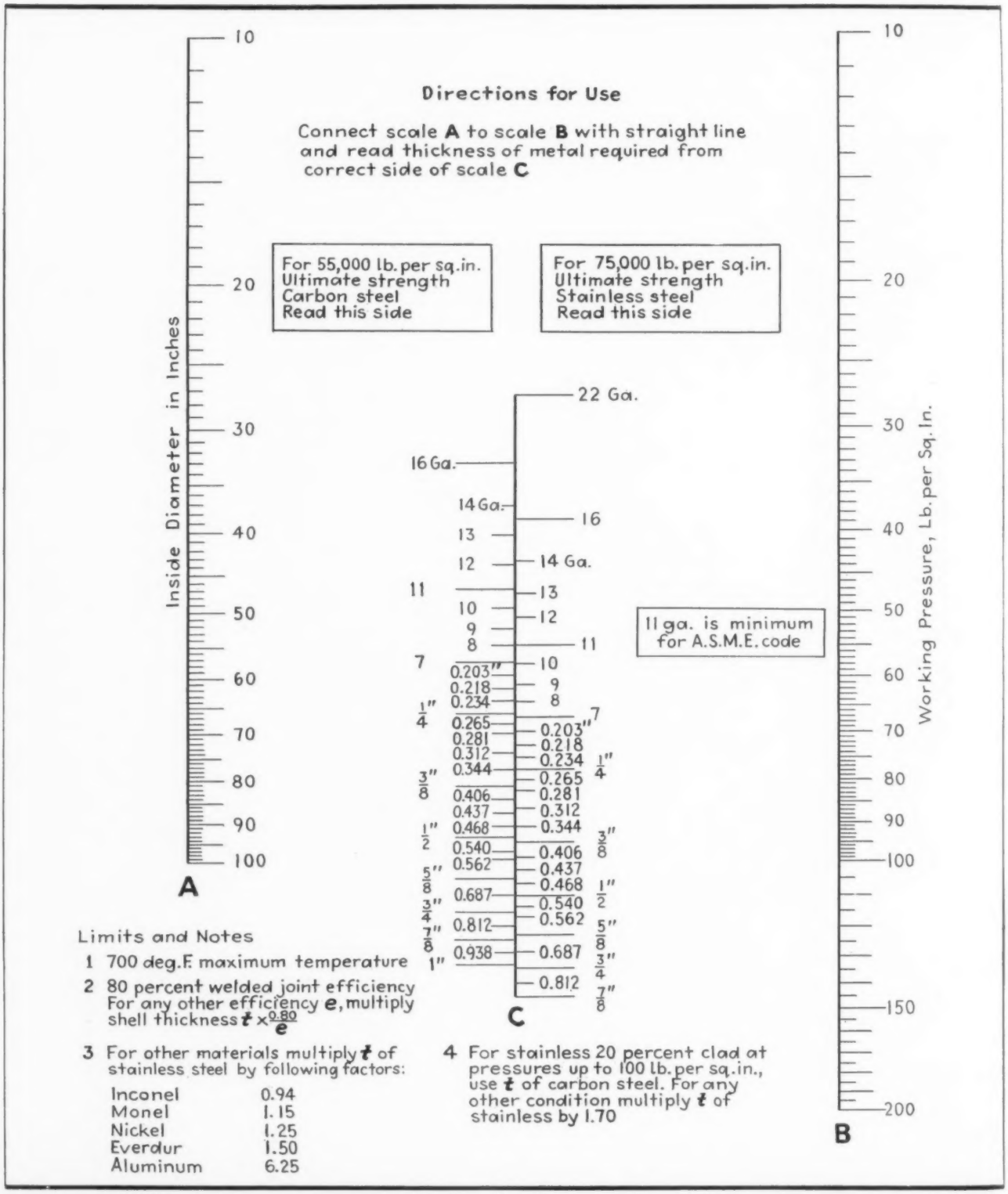
A tank 54 in. in dia. and 96 in. long has a steam jacket around it operating at 100 lb. per sq.in. The length of this jacket is 83 in. Find the required shell thickness.

Starting with the length of straight shell of 83 in. on the chart above, follow arrows and dotted line to solution of 0.54 in. thick.

(Chart based on A.S.M.E. Code Par. U-122)

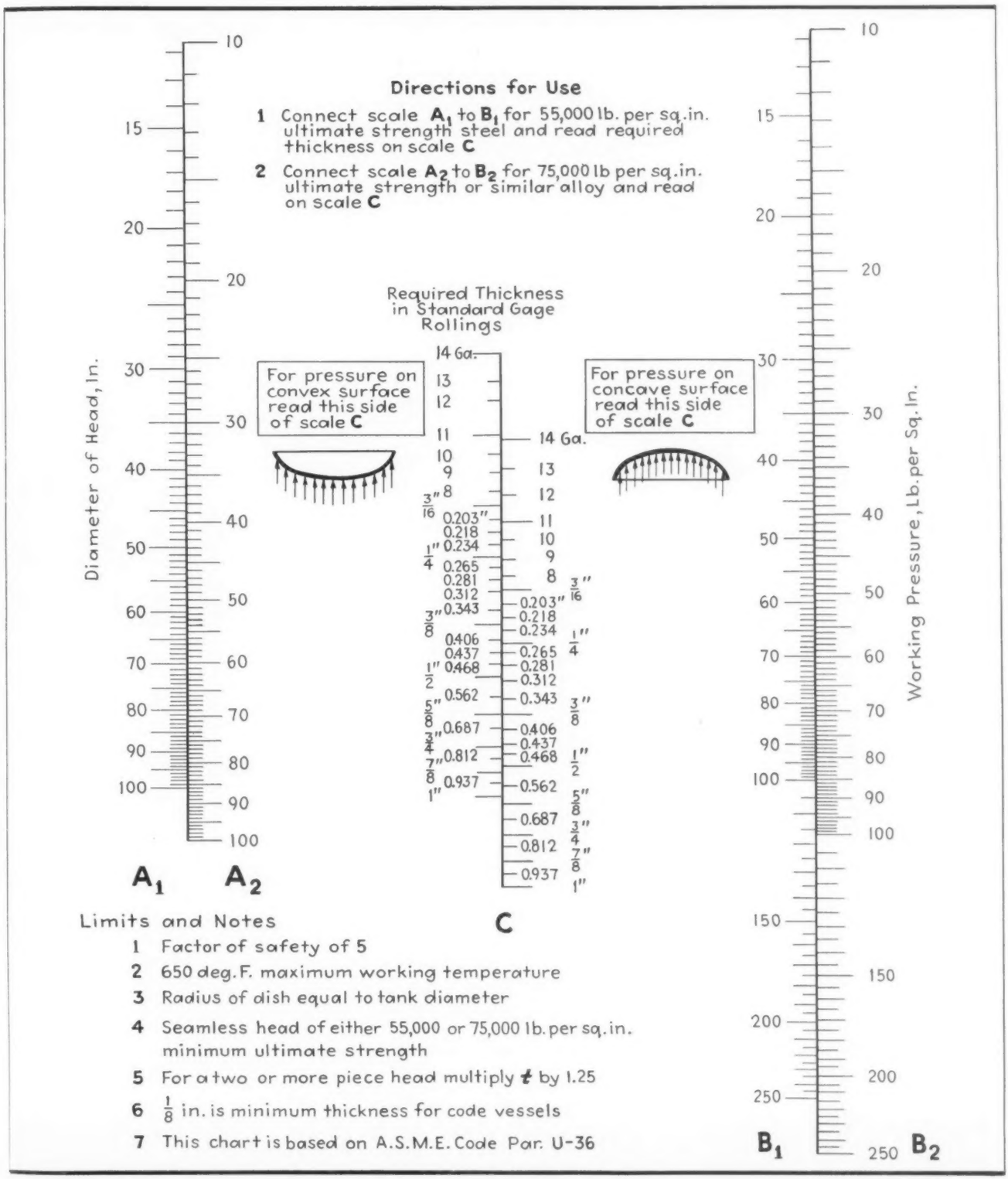
Unfired Pressure Vessels (continued)

SHELL THICKNESS—INTERNAL PRESSURE


Directions for Use
Connect scale A to scale B with straight line and read thickness of metal required from correct side of scale C
For 55,000 lb. per sq.in. Ultimate strength Carbon steel Read this side
For 75,000 lb. per sq.in. Ultimate strength Stainless steel Read this side
Inside Diameter in Inches
Working Pressure, Lb. per Sq. In.
A
B
C
11 ga. is minimum for A.S.M.E. code
Limits and Notes
1 700 deg.F. maximum temperature
2 80 percent welded joint efficiency For any other efficiency e, multiply shell thickness t × 0.80/e
3 For other materials multiply t of stainless steel by following factors:
Inconel 0.94
Monel 1.15
Nickel 1.25
Everdur 1.50
Aluminum 6.25
4 For stainless 20 percent clad at pressures up to 100 lb. per sq.in., use t of carbon steel. For any other condition multiply t of stainless by 1.70

Unfired Pressure Vessels (continued)

DISHED HEAD THICKNESS

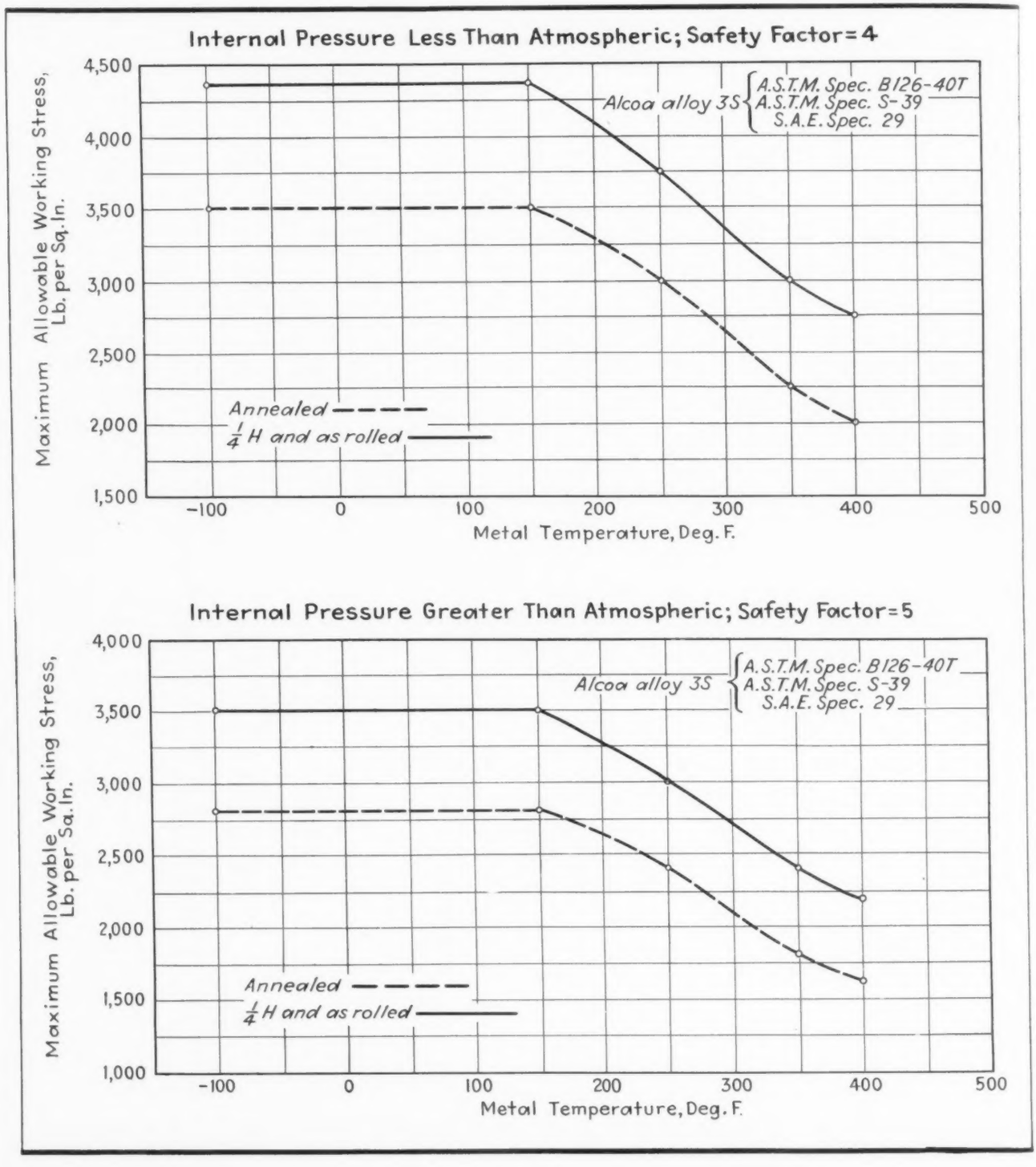


Limits and Notes

1 Factor of safety of 5
2 650 deg. F. maximum working temperature
3 Radius of dish equal to tank diameter
4 Seamless head of either 55,000 or 75,000 lb. per sq. in. minimum ultimate strength
5 For a two or more piece head multiply t by 1.25
6 $\frac{1}{8}$ in. is minimum thickness for code vessels
7 This chart is based on A.S.M.E. Code Par. U-36

ALUMINUM UNFIRED PRESSURE VESSELS

Maximum Allowable Working Stresses



PRODUCT ENGINEERING ✦ REFERENCE BOOK SHEET

Advertisement JULY, 1941

COPPER ALLOY BULLETIN

REPORTING NEWS AND TECHNICAL DEVELOPMENTS OF COPPER AND COPPER-BASE ALLOYS

Prepared Each Month by the Bridgeport Brass Co. "Bridgeport" *Headquarters for BRASS, BRONZE and COPPER*

Copper Sheet is Good Base for Silver Plate

Copper sheet is used as a base for the production of silver plated articles because it is easily and economically stamped into desired shapes, and because it is particularly well adapted to electroplating and finishing. Bridgeport copper sheet with its uniform high quality, made possible by the company's new and up-to-the-minute equipment, is considered excellent for this purpose. It is helping manufacturers of silver plate achieve highly satisfactory results at economical cost.

Easy and accurate stamping of copper sheet supplied by Bridgeport is made possible by Bridgeport's carefully controlled manufacture.

Three-Step Procedure For Cleaning Alloys

A new method of cleaning brass, bronze and copper preparatory to plating gives a sequence of operations said to produce economies, superior plating color and better plate adhesion.

The process comprises three steps: (1) Effective pre-cleaning of the work with either an alkaline compound or an emulsifying solvent, depending on the condition and shape of the pieces; (2) Anodic cleaning with an alkaline electro-cleaner prepared for this particular purpose; and (3) A sulphuric acid dip. The work is rinsed, of course, following each operation.

Incomplete removal of oils, greases and dirt has always been considered a cause of poor electrodeposits. The new process is said to be capable of eliminating all types of oil and dirt. Moreover, it is reported to do away with the smutty deposits and soap films that contribute to poor adhesion of the electrodeposit. A further advantage is the slight etch it provides on alloys, which also makes for better adhesion of the electrodeposit.

Progress is Made in Substituting Copper for Brass in Varied Uses

Factors to be Considered Include Oxygen Content of Copper Used, Comparative Machinability, and Need for Retooling

In considering the possible substitution of copper for high brass, there are different types of copper which will provide slightly different specific properties that may be of advantage. The properties of these various types of copper were discussed in the "Types of Copper" column in the COPPER ALLOY BULLETIN from May to July, 1939.

One of the differences not previously mentioned in the present series of articles is the effect of oxygen content on the machinability of copper. While high brass is not commonly expected to be readily machined, it can be done fairly well when in the cold worked condition. None of the various types of copper, however, is as readily machinable as cold worked high brass. Annealed copper is particularly tough and machining speeds must be greatly reduced in order to cut it at all. Copper containing particles of cuprous oxide such as regular electrolytic tough pitch copper is somewhat superior to deoxidized copper in this respect. This is due to the presence of the copper oxide particles which tend to break up the otherwise long stringy chips. The cutting tool edge must have considerable rake and clearance. This type of cutting edge tends to produce long chips and therefore drilling and tapping operations are particularly difficult. Copper which must be machined should be in the cold worked condition and of the tough pitch type, but even under the best conditions, it is not an easy operation compared to high brass.

Tubing and Stampings

During the past few months some progress has been made in the substitution of copper for brass. In most cases these are the simple types of fabrications, but a few have required some care and planning in order to get satisfactory products of copper. The use of copper tubing in the plumbing industry has been quite extensive. High brass pipe has been replaced quite generally by red brass and copper pipe. The thin wall tubes used in exposed plumbing fixtures, which are normally chromium plated, have been replaced by deoxidized copper. In both these cases deoxidized copper has been used because its ductility is sufficiently greater than tough pitch copper to permit severe bending operations.

There has also been some copper used for name plate work and flat stampings of that general type. Consideration is also being given to the use of copper in small pressure vessels which can be made from cold worked material and soft soldered without softening of the vessels themselves. There also seems to be a field for copper in flashlight parts and bodies, for these parts have been made of copper in the past and it seems probable that most of them could be made of copper without the use of special tools and extra operations. Some parts used in electrical hardware normally made of brass would seem to be suitable for a change over to copper.

Desirability of Retooling

When this series of articles was started, the scarcity of zinc for use in non-defense applications was the primary consideration. As the defense program has developed, the need for copper for defense purposes has reached the point where the desirability of such substitution needs consideration from a somewhat different viewpoint. When the use of copper requires extensive tool changes as it does in some cases, it is questionable whether the machine tooling required for such changes is justifiable. From the production standpoint it seems possible that the substitution of copper may be desirable only because it saves a remelting operation which might be better used for essential defense work than for other purposes. It is well to bear these considerations in mind, therefore, when planning changes from alloys to pure copper. The accompanying table lists some of the physical properties of high brass and commercial copper.

PROPERTY	COPPER	HIGH BRASS
Specific Gravity, 20°C	8.94	8.47
Density, lbs./cu. in.	0.323	0.306
Linear Coefficient of Expansion @ 25°C	16.8 x 10^{-6}/°C	19.0 x 10^{-6}/°C
Electrical Resistivity, 20°C	1.682 microhms/cm^3	6.68 microhms/cm^3
Electrical Conductivity, 20°C	100%	25.85%
Thermal Conductivity, 20°C	0.923 cal/cm^2/cm/sec/°C	0.286 cal/cm^2/cm/sec/°C
Specific Heat	0.0918 cal/gr/°C	0.0909 cal/gr/°C
Modulus of Elasticity, cold worked	16,000,000 lbs./sq. in.	14,500,000 lbs./sq. in.

COPPER ALLOY BULLETIN

ALLOYS OF COPPER

This is the twenty-fifth of a series of articles on the properties and uses of copper alloys, and continues the subject of modifications of the copper-zinc alloys.

ADDITIONS OF LEAD TO COPPER-ZINC ALLOYS

Because of purely manufacturing considerations, the addition of lead to copper-zinc alloys (to improve machinability) is usually confined to the range from 55 to 63% copper. Occasionally, however, lead has been added to pure copper and other alloys from 90-10 copper-zinc on down to 55% copper.

The addition of lead reduces the ductility of the copper alloys in both hot and cold working operations. Those alloys which are normally the most difficult to hot work are the alloys most seriously affected by the presence of lead. Hence the alloys with copper contents above about 63% and containing additions of lead have been processed almost entirely by cold working. Such alloys, besides being difficult to hot work, are also sensitive to processing variables in cold working. Thus the use of some otherwise very desirable alloys has been restricted by the excessive cost of manufacture.

Those alloys containing less than 63% copper are two-phase alloys above about 700° C. This second phase, beta, is much more ductile in that range of temperatures and the lead does not seem to reduce its ductility to the extent that it does the alpha phase. For this reason, alloys around 60% copper can be produced readily by hot working even when containing appreciable quantities—2 or 3% for instance—of lead.

The accompanying table lists the commercial leaded alloys normally available:

Special File For Brass

Filing brass is quite different from filing other metals, says a leading file maker. While brass is generally softer than ferrous metals, it is malleable, ductile and tough. Thus, a regular or general purpose file will cut brass rapidly enough for a few strokes. Then the teeth tend to clog rapidly and consequently slip over the metal surface, without removing much stock.

A special brass file that will correct this, the file manufacturer claims, has a combination of tooth angles and number of tooth points per inch to give excellent results. It possesses a long overcut angle and a short upcut angle. The short upcut angle keeps the file on the work, while the long overcut angle, producing many fine scallops on the short upcut, breaks up the filings. This permits the file to clear itself of chips. In other words, this prevents the file from taking too much of a bite and eliminates clogging and chattering. It is also said to leave a good finish.

Filing of brass involves a special technique. Inset shows tooth design of brass file.

COMMERCIAL LEADED COPPER-ZINC ALLOYS

ALLOY	ASTM	ALLOY NO.	COPPER	ZINC	LEAD
Leaded Commercial Bronze	B- 41T	B	88.5	9.5	2.0
Hardware Bronze	B- 41T	A	85.0	13.0	2.0
Leaded High Brass	B135-40T	3	66.0	33.5	0.5
Leaded Brass Tubes	B135-40T	4	66.0	32.4	1.6
Clock Brass	B121-39T	5	63.0	35.0	2.0
Leaded Naval Brass	B21-40T	B	60.5	39.0	0.5
Forging Rod	B124-39T	2	60.0	38.0	2.0
Leaded Cold Heading Rod			63.0	35.4	1.6
Screw Machine Rod	B16-29		61.5	35.5	3.0

NEW DEVELOPMENTS

Electroplating brushes which are said to be practically unaffected by normal plating solutions are now available. They do not deteriorate rapidly, as do hog bristles. They are called soft enough for use even with such deposits as silver. **(No. 210)**

A welder's glass for use in helmets is reported to cut off most of the infra-red rays and all of the ultra-violet rays, thus preventing distress and injury to the eyes. Moreover it makes possible better observation and more accurate control of the flow of metal, it is said. **(No. 211)**

A sheet metal gage measures the thickness of brass, copper and other non-ferrous metals from one side only, without contacting reverse side. It is recommended for use with copper tanks, brass pipe and many other applications. **(No. 212)**

A sander-polishing machine, though small and portable, is designed to give heavy-duty, continuous service. This bench-type belt sander-polisher is said to be well adapted to use on edges, irregular work, curves, flat pieces, small members and small radii. **(No. 213)**

An air-line dehydrator utilizes easily-renewed silica gel as moisture-removing agent. Fresh supply is quickly screwed in. The shell is made of brass with brazed joints, and the outlet screen is 200-mesh brass. **(No. 214)**

A tool grinding fixture holds cutters for sharpening on drilling machines. Fixture is readily tightened on drill table and will hold straight or taper shank tools up to 1-in. in diameter, including end-milling cutters, counterbores, and facing cutters, it is said. Cup grinding wheel rides in drill spindle chuck. **(No. 215)**

Marking tool with solid die is said to automatically make clean-cut identifying marks in high production on parts such as shells and other ordnance and non-ordnance parts. Used on automatic screw machines or lathes. **(No. 216)**

A hexagon bed turret, designed to step up bench and engine lathe production to a rate comparable with that of hand screw machines, is announced. It is said to have many new automatic features and is designed to fit many makes and sizes of lathes. **(No. 217)**

A soft rubber polishing wheel has an improved composition which rapidly produces highly polished surfaces on any base metal, it is reported. It is said to greatly reduce polishing time because of the 5 different types of polishing compounds impregnated in the binder. It can readily be dressed for contours. It also eliminates scratches and blemishes, it is claimed. **(No. 218)**

This column lists items manufactured or developed by many different sources. Further information on any of them may be obtained by writing Bridgeport Brass Company, which will gladly refer readers to the manufacturer or other source.

PRODUCTS OF THE BRIDGEPORT BRASS COMPANY

Executive Offices: BRIDGEPORT, CONN.—Branch Offices and Warehouses in Principal Cities

SHEETS, ROLLS, STRIPS—*Brass, bronze, copper, Duronze,** for stamping, deep drawing, forming and spinning.

CONDENSER, HEAT EXCHANGER, SUGAR TUBES—For steam surface condensers, heat exchangers, oil refineries, and process industries.

PHONO-ELECTRIC* ALLOYS—High-strength bronze trolley, messenger wire and cable.

WELDING ROD—For repairing cast iron and steel, fabricating silicon bronze tanks.

LEDRITE* ROD—For making automatic screw machine products.

COPPER WATER TUBE—For plumbing, heating, underground piping.

DURONZE ALLOYS—High-strength silicon bronzes for corrosion-resistant connectors, marine hardware; *hot rolled sheets* for tanks, boilers, heaters, flues, ducts, flashings.

BRASS, BRONZE, DURONZE WIRE—For cap and machine screws, wood screws, rivets, bolts, nuts.

FABRICATING SERVICE DEPT.—Engineering staff, special equipment for making parts or complete items.

BRASS AND COPPER PIPE—"Plumrite"* for plumbing, underground and industrial services.

*Trade-name.

"Bridgeport" BRASS CO.

Established 1865

BRIDGEPORT BRASS